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for Economic Cooperation
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Sustainable Energy for Food

Challenges and Solutions for Sustainable Energy Use in the Agriculture and Food Industry

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Preface

According to conservative estimates, producing food and getting it to the table accounts for around 30% of energy consumed worldwide, most of which is provided by fossil fuels. In places where renewable energies such as biomass already drive agricultural value chains, particularly in the developing world, they often originate from traditional sources – fuelwood, for example, which in most cases is harvested in unsustainable ways. With world population on a path of unbridled expansion and energy resources in dwindling supply, experts in science, business, civil society and development cooperation who are active in the energy and food sectors all face the same problem: how do we produce more food using as little energy as possible, while increasing the share of renewable energy? The GIZ-DIE symposium 'Sustainable Energy for Food', held on 12 June 2014 in Bonn, Germany, placed itself at just this juncture.

With a line-up of 16 speakers drawn from development cooperation and research in energy and agriculture, the symposium sought to provide a comprehensive overview of where the various stakeholders stand on the issue. Input from project managers, researchers and finance officers in working groups during the afternoon hours supplied additional perspectives rooted in hands-on experience. Collaboration and project work are crucial to making progress in the overlapping areas of sustainable energy and food, for although the international community finds itself facing unprecedented challenges within this nexus, possible solutions are to be found there as well; indeed, energy- and climate-smart technologies and practices, as the FAO has come to call them, already abound in agri-food systems. The challenge is to identify them and to fully develop their upscaling potential. The ultimate obstacle looming over any effort that targets sustainable energy and food, be it a small-scale applied project or a sweeping international campaign, is also the key to its success: mainstreaming.

Recognising that knowledge management and dissemination are of utmost importance to achieve excellent results in the field, the German Federal Ministry for Economic Cooperation and Development (BMZ) joined forces with the United States Agency for International Development (USAID) the Swedish International Development Cooperation Agency (SIDA), OPIC and Duke Energy to found to found the global initiative 'Powering Agriculture: An Energy Grand Challenge for Development'. The overall objective is a shared one: the integration of innovative clean-energy solutions into developing countries' agriculture sectors as a means of increasing agricultural productivity and value. On behalf of the German Ministry, GIZ implements the German contribution to the international initiative and complements its activities through the project 'Powering Agriculture – *Sustainable Energy for Food*'. Under this theme, GIZ focusses on knowledge management and networking, training and implementing model projects in cooperation with private and public partners. The symposium was a kick-off meeting for a network of experts on the energy and food nexus, designed to spawn designed to spawn personal contacts within what has up to now been a very loosely knit community. The lively exchange and sharing initiated there will continue, it is hoped, on a newly founded virtual platform, the Powering Agriculture wiki portal. This documentation is intended to serve as one of its resources, and as a stimulus for further discussion.

Be part of the solution!

Contribute to the global knowledge network for energy and food. Subscribe to the PoweringAg Newsletter at

→ www.PoweringAg.org

or register at

→ https://energypedia.info/wiki/Portal:Powering_Agriculture

More than 4,000 users have already signed up!

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***Dr Stefan Schmitz**, Head of Special Unit 'ONE WORLD – No Hunger', German Federal Ministry for Economic Cooperation and Development (BMZ)*

Opening Address: Dr Stefan Schmitz delivering his talk at the symposium

Energy and food intersect in many ways and on many different levels. One such area of overlap, and a very critical one indeed, is what has come to be called in expert circles the 'food and fuel', or 'food *or* fuel' problem, which refers to the increasing competition for agricultural land between food production and energy crop cultivation. Likewise, the markets for energy and food are closely intertwined globally, with spikes in one market often leading to similar rises in the other. More important, however, is the central role energy plays in all stages of the agricultural value chain, from producing and processing food crops to preparation and cooking at the end-consumer level. A direct link therefore exists between poverty (and its alleviation) and access to energy. Food production requires energy, invariably. Yet energy – like so many other resources in the world – is finite. No matter what angle you look at it from, it is clear that energy and food lie equally at the heart of sustainable development.

One side of the equation: Food, hunger and malnutrition

Food supply, in particular, has become a key political issue of late; it represents an area of prime concern for the German Federal Ministry for Economic Cooperation and Development. According to the Food and Agriculture Organization of the United Nations (FAO), more than 800 million people around the world suffer from hunger today, with yet another one billion affected by malnutrition, the so-called 'hidden hunger'. This is an ethical scandal of truly immense proportions. No other human right is breached more often than the right to food and well-being. From the perspective of development policy, however, the problem transcends the domain of ethics alone: people who are starving, who are malnourished, particularly the very young, fail to grow to their full mental and physical potential. A starving generation is a lost generation for development cooperation, because hunger reshapes a life in a way that cannot be undone even in later times of prosperity.

The German government's response: 'ONE WORLD – No Hunger'

To address the issue in all its dimensions, the new German development minister, Dr Gerd Müller, has announced the launch of 'ONE WORLD – No Hunger'. The initiative is de-

Threshing grain: One of the many forms in which energy enters agricultural production and processing

signed primarily to secure access to food for the poor on a worldwide scale, but will also serve to refocus development policy in general, with a stronger emphasis on the utilisation of food that is nutritious. One main objective will be to provide a stable and secure supply of food over time by enhancing resilience and fighting hunger in regions of crisis, catastrophe and conflict. In order to achieve this, many changes and developments will be required: continuous innovation within agriculture and along the entire agricultural value chain, comprehensive structural change in rural areas, as well as a shift towards a more sustainable use and conservation of the natural resources needed for agricultural production. People must have secure and equal access to land and to the resources it provides. Food security, in this respect, also relates to questions of water and wastewater management, hygiene, health, education and more.

The other side: Energy access, resource consumption and wastage

Energy is central to most of these issues and may justly be called the basis for development. People need access to energy for food production and consumption, as well as for everything in between along the agricultural value chain: storage, processing and transport, for example. However, those who have access to energy – and there are many these days, luckily – do not always use it in a very efficient way. On the contrary, much of the food that is produced using large amounts of energy is subsequently lost along the value chain. Either it is simply squandered, or the poor design of production operations, particularly in developing countries, eats away most of the raw materials and what is invested along the way. Next to energy access, resource consumption and wastage are the biggest issues that need to be addressed when devising systems of sustainable energy for food.

Further variables in the equation: Interrelatedness of factors

The problem extends well beyond the two poles of energy and food, though – to water supply, for instance. The German government can be credited with introducing a term to international debate that captures the interrelatedness of factors in this domain; namely, that of a 'nexus' between water, energy and food security. This concept has now become common among development experts; however, there is an imminent danger in broad umbrella terms of

A full conference hall: About 90 experts from development cooperation, research and business attended the symposium

this kind. By simply stating the obvious, as they essentially do, they tend to keep debate at a very general level, making it all the more important for us to focus in on specific aspects of the big issue in question. The answers here do not necessarily equate to technology. Far from being negotiated deep down in the engine room of development policy and cooperation, 'Sustainable Energy and Food' is above all a topic for the political agenda. It revolves around questions of institutional design, of financing, incentive systems, public expenditure and the role of the private sector. Why not, for example, put in place a global innovation system that bridges and enhances research, education, training and counselling in the field?

Challenges for global development policy and cooperation

Next year the international community will convene to adopt a new global target system for sustainable development as part of what is known as the 'Post-2015 Development Agenda'. The German government is using its influence to give global food security a prominent, if not central, place in this agenda. With 800 million people suffering from hunger, and an even greater number affected by malnutrition, the task is undoubtedly a very urgent one. Many of those who are starving need better access to energy in order to overcome both their poverty and their hunger. At the same time, agriculture and the global food industry need to be put on a path of sustainable development if they are still to feed the world in 50 or 100 years' time. The challenge is clearly one of today, yet it also extends into the future, for an intensification of agricultural practices is inevitable given this set of conditions. It is high time then to change a phrase heard only too often in the discussions surrounding sustainable development: we must finally move on from 'producing more with less' to 'producing more *food* with less *energy*'.

Keynote:
Sustainable Energy for Food

***Dr Tilman Altenburg**, Head of Department 'Sustainable Economic and Social Development', German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE)*

From the perspective of development cooperation, 'Sustainable Energy for Food' is essentially a problem of three highly interconnected factors: the effects of poverty reduction efforts; the existence of limited resources, both in terms of energy supply and agricultural production; and the overall nature of the global food system, which for all intents and purposes is far from sustainable. Each of these factors merits its own analysis and can in fact be broken down into smaller subsets of interrelationships and causal connections.

Poverty reduction: more energy, more intensive land use

Alleviating poverty, at least where food supply is concerned, almost always means intensifying agricultural practices and production, and this in turn requires an increase in energy input. Access to electrical energy – the 'forgotten millennium goal' – is fundamental not only to increasing food production and thus relieving hunger, but also to a wide array of other social and economic dimensions, from education and health services through to rural manufacturing. All these dimensions require energy and compete with each other for the limited resources available. Numbers are staggering indeed: 1.6 billion people around the globe do not have access to electricity, and 3 billion rely on energy from biomass for their basic needs such as cooking and heating. In Africa, food output rates have stagnated since the 1970s, and the absolute number of undernourished people has doubled in consequence: currently it stands at a mind-boggling 180 million.

Scarcity of energy and agricultural resources

Clearly, there is an urgent need, from both an ethical and a developmental perspective, for poverty reduction, and therefore a need for intensification in agriculture; at the same time, however, energy resources are being rapidly depleted, putting agricultural lands under additional stress. This increased strain is a consequence of the rise in biomass

Jatropha curcas, whose oil-rich seeds can be processed to produce a high-quality biodiesel fuel

'Powering Agriculture' or 'Sustainable Agri-Food Systems': Options for a new paradigm in development cooperation?

production that itself developed in response to energy scarcity and rising demand. Energy crops, however – in contrast to earlier hopes that they would grow on marginal soils only, such as in the case of Jatropha – are increasingly entering into direct competition with food crops. The situation for development cooperation is paradoxical: The production of the energy required to step up food production for alleviating poverty will at the same time encroach upon the very land that the food is produced from. What is more, food production alone already accounts for 30% of global energy consumption (FAO estimate).

Global food system not sustainable from an ecological point of view

The system as it stands is highly unsustainable: 22% of greenhouse gas emissions, according to FAO, originate in the global food system. Production patterns tend towards monoculture and threaten biodiversity – in the developing world as much as in the developed world. A diverse agricultural landscape in the northern German federal state of Schleswig-Holstein, for example, has given way in the wake of the biodiesel boom to endless fields of rapeseed, extending from the Baltic Sea to the North Sea. Monocultures, of course, are also known for being water-guzzlers and for leaching soils. Unfortunately, wastage holds for the entire system: one third of all food produced worldwide remains unused. Strong interdependencies and connections exist throughout, resulting in targets and objectives that are often in conflict. Output in biomass production, to give but one example, should ideally be weighed against soil fertility; and a solar pump, though renewable, does not do away with constraints on water management.

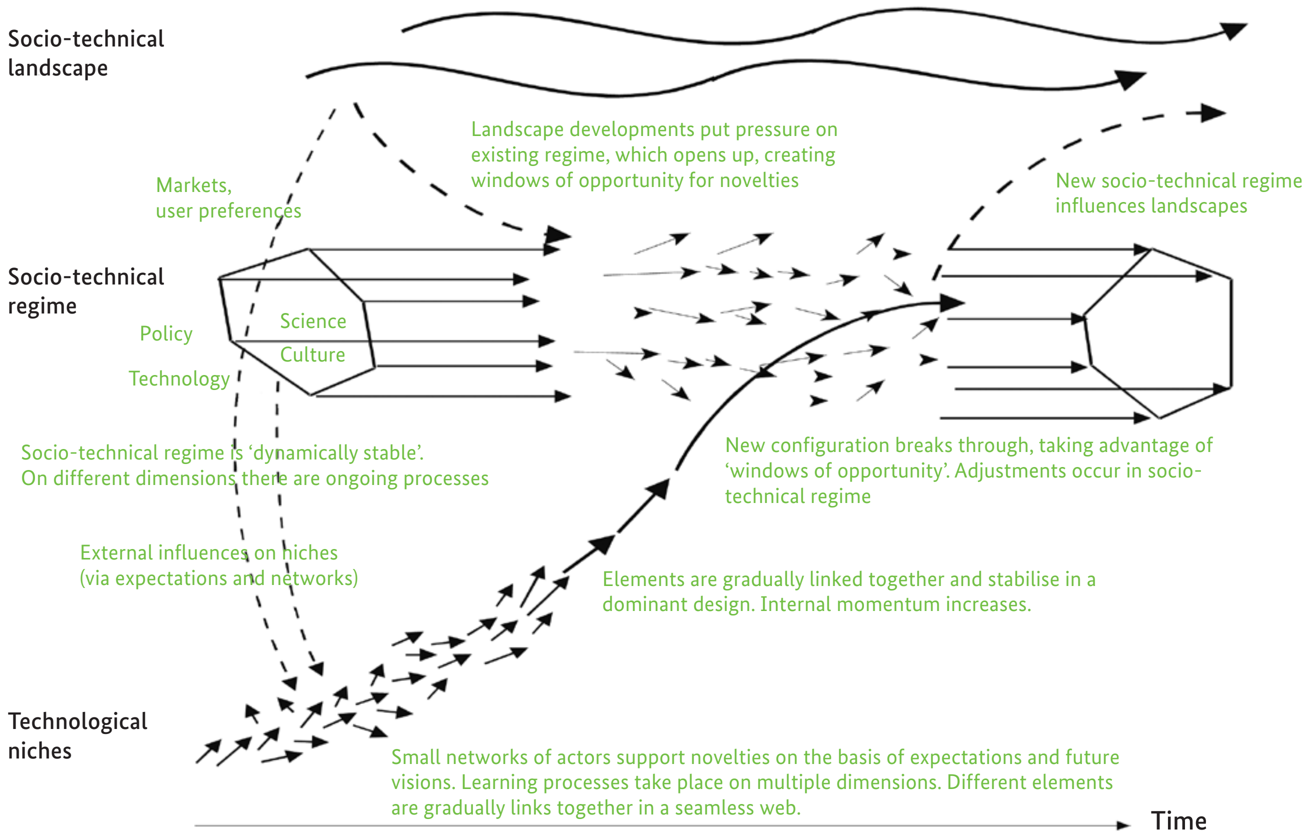
A formidable challenge for development cooperation

The challenges for development cooperation are significant: How can we achieve more with less? How can we feed more people, in a better way, with improved access to modern energy, yet without consuming more water and soil, or generating more greenhouse gas emissions? Phrased as a direct question to the symposium, we could ask: what do integrated systems for sustainable food and energy production look like? Though formidable at first glance, the challenge is indeed not insurmountable, for technological solutions do exist. There are already a great number of agricultural production systems in the world that have at their core an eco-system approach, that make allowances for biodiversity and work on the basis of local energy and material cycles. Livestock's contribution to agricultural production as a consumer of silage and a producer of manure or fuel (dung) is one well-known example in this respect. Sustainable agroforestry systems that boast highly impressive rates of production are another.

Technical feasibility: *Energy for All*

In the energy sector, too, solutions abound. Renewable energy sources can be harnessed for energy and fuel production in the form of energy crops or – better so, because more efficient – as agricultural byproducts in second-gen-

Sustainability Transitions



From technological niches to socio-technical regimes and landscapes (Geels, 2002)

eration biomass production. Wind, solar and water energy are available at most sites, grid-based or as independent units; in only 20 years' time, they could supply 100% of global energy demand. There is after all a huge potential for energy savings throughout the agricultural value chain, as much with regard to outdated, inefficient forms of production, processing, transport and retailing within the developing world as to wasteful consumption patterns within the developed world. Through grid expansion or decentralised, on-site production, even the most remote places can be furnished with electricity. The triple call of the UN's Sustainable Energy for All Agenda – accessible, cleaner and more efficient energy – is technically within reach. Given this, where do the problems in the energy and food nexus stem from?

Where things need to change

Again, three factors seem to have hampered the application of models and solutions so far; the first is knowledge and paradigms. Sustainable systems must always be adapted and optimised for each individual site. Many of the paradigms guiding development cooperation still hail from a time when energy supply and carbon sinks were thought to be boundless. Technical and socio-economic problems are another important factor. Land productivity in agroforestry, for example, can indeed be very high, yet most processes are also very labour-intensive and resist mechanisation. As a result, possibilities for economies of scale, or scope, are scarce in agroforestry, and production successes in most cases cannot be replicated on a macroeconomic level. Upscaling, so to speak, is the technological opposite of local adaptation; it must be remembered that both small and large are beautiful.

Biased political institutions and incentive systems

The core problem, however, lies elsewhere: political institutions and incentive systems are what need to change first. There is no point in developing the most exemplary systems of regional energy or food production if political frameworks do not permit their application. All too often, agricultural incentives and subsidies favour mechanisation and monoculture over biodiversity and decarbonisation; energy consumption and artificial fertilisers over energy

efficiency and integrated natural manure cycles; and centralised energy systems based on fossil fuels over independent power producers (IPPs) and plants running on renewable energy sources. Legal uncertainty often exists about property and land use rights, and political institutions tend to stay confined to their respective domains rather than cooperate across departments and responsibilities.

What are the consequences for German development cooperation?

If support frameworks are decisive, development cooperation, too, needs to redefine its paradigm, away from the 'Green Revolution' that multiplied agricultural output in Asia and towards a new vision: 'Powering Agriculture', as in the American example – and, incidentally, the present initiative's title. Or rather, 'Sustainable Agri-Food Systems'?

It is imperative for development cooperation to reflect the complexity of the target systems it deals with. Programmes and approaches must be systemic, allowing for cooperation across institutional boundaries and combining agricultural, energy, and structural policies. Diversity must be recognised where it is due – one size does not fit all. In sustainable agriculture in particular, solutions need to be site-specific. Instead of using blueprints masterminded in far-off headquarters, organisations should conduct their research and development locally. In fact, it is only through the 'upscaling' of results obtained in decentralised settings, in 'niches' involving new actors and new approaches, that dominant paradigms can be changed. Effective development cooperation will acknowledge and negotiate between both levels – both the local 'niche' experiments and the larger socio-technical, economic, and political structures – in order to achieve a true 'sustainability transition'.

Sustainable Energy for Food: Dr Tilmann Altenburg delivering his talk at the symposium

Energy Interventions in Agricultural Value Chains for Enhancing Food Security

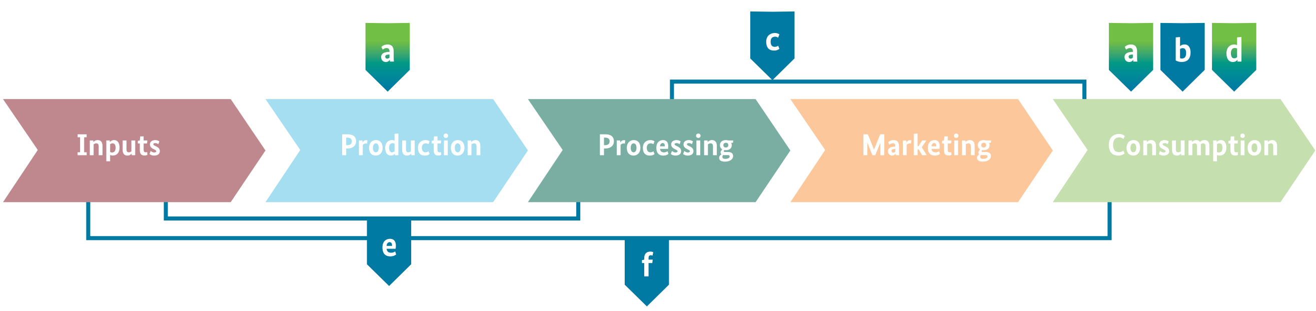
Dr Michael Brüntrup, *Researcher, Department 'Sustainable Economic and Social Development', German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE)*

Along agricultural value chains, from the most basic processes of food production to consumption at end-consumer level, energy and food are linked in many different ways. This interlinkage varies greatly with the chain concerned, with the specific energy inputs required at each step, the sources and carriers of these, and also according to the level of food security that is actually attained along the way – which again can be highly variable. The energy and food nexus may thus be viewed from very different angles and at various operational distances: it may be approached for example as a pressing political concern, as with emergency relief in regions of famine, or as the objective of a systematic, long-term change from a more strategic, global perspective. According to the Food and Agriculture Organization of the United Nations (FAO), 80% of energy in the food sector is needed during the later stages of production – in processing, marketing and transport, far removed from agriculture proper. It is here that large-scale deployment of renewables and energy-efficiency measures can achieve best results with regard to reducing the adverse environmental effects of energy use. This holds for high-income countries with highly sophisticated systems of food production and processing as well as for poor countries with technologically very basic systems. However, given that FAO estimates more than 840 million people are still suffering from hunger around the world, the focus of development work should remain firmly set on food security in poorer countries and regions. Energy scarcity here still looms largest and tends to eclipse all other concerns within the energy and food nexus.

Agricultural value chains and food security

How can food, and more generally agricultural, value chains contribute to food security under these premises? Where and how do changes in energy supply and its utilisation along these chains affect, and possibly enhance, the situation of those whose supply of food is insecure? Food-insecure people in poor countries could conceptually be grouped into two camps: (i) smallholder farmers with insufficient subsistence production, either permanent or temporary; and (ii) non-farming consumers – both rural and urban, who rely on insufficient or irregular income-generating activities and on the market to purchase food. The distinctions between these two groups however are blurred by the fact that most poor households fall somewhere in between each pole: they produce agricultural goods yet also purchase some of their food on the market. The widely varying situations of food-insecure households complicate any assessment one might make of the links that really exist between energy and food security.
The figure below is a schematic representation of an agricultural value chain – understood as a basic sequence of inputs, production, processing, marketing and consumption.

Systematic representation of an agricultural value chain



Value chains in real-life tend to be much more complex, with many more intermediate steps, side-products, recycling, etc. Some steps and areas in these value chains are typically of greater importance for food security than others: in the context of small-scale farming and husbandry in developing countries, food production for subsistence is one such central aspect. If energy interventions succeed in raising the level or stability of food production, this has an immediate effect on poor smallholders. Additional income for buying foodstuffs may then be generated by growing cash crops for the market, which also happens to benefit (end-)consumers. The type of cash crop is decisive for how food security will ultimately be affected: while the production of surplus food in this regard is without risk, non-edible cash-crop production may enter into conflict with that of food. Then again, non-edible cash-crops also enable much higher income from given farm resources, while income from surplus food crops is subject to price volatility on local food markets, themselves determined by a high co-variance of supply and demand. Cash income, indeed, may not always improve food security, for everything depends on how it is eventually spent. The income of women, for instance, has proven to contribute more to food security than that of men. Changing cultivation patterns can therefore be a benefit or a detriment to making a food supply more secure. One outcome is certain though: using the money earned by selling food and/or cash crops for sustenance represents one step towards dissociating, and formalising the distinction between, agricultural production and food consumption – a trend which is observable throughout all societies and times as economies develop and branch out from agriculture.

Processing, beyond its main function of converting basic agricultural products into foodstuffs of higher (added) value, also has the potential to create jobs for unskilled labour, labour typically provided by very poor, food-insecure households. An increased, more stable and less expensive energy supply in rural areas improves and expands local processing and value-adding, and thus helps create these jobs. This will ultimately raise food security, too, as untrained workers, particularly in sub-Saharan Africa (SSA), are among the most vulnerable in terms of poverty-induced malnourishment and starvation. A better local energy supply should also contribute to making low-priced food available for consumers outside the agricultural sector, both rural and urban, and protects against vulnerability from transport costs, and thus energy-sensitive international markets. Strategic interventions in agricultural value chains, even if initially only aimed at one particular step or area of production, may bring about so-called 'spill-over effects' and yield benefits across the entire chain concerned, or even over an entire rural area. In Benin, for example, promoting cotton as a cash crop boosted farming systems as a whole, since innovations and capital introduced into the cash-crop sector (e.g. animal traction and mineral fertilisers) could be carried over into food production as well. Notably, cotton farming became a hotbed for farmers' political action, and organisations founded in this domain went on to encompass food issues, too. If energy interventions are large enough, they may stimulate rural economies and boost off-farm jobs and income as 'motors' of a more general development. Tweaking the parameters of agricultural value chains at the energy level thus always entails changes in the technical, social, economic and even political domains. As a rule, labour-intensive agriculture, which is still typical of most poor developing countries, continues to be the major force for rural development and poverty reduction. Increases in production here have a strong multiplier effect, since profits generated are for the most part spent on local products and services. In the long run, this will reduce the predominance of the agricultural sector itself.

Priorities: Hunger and sub-Saharan Africa

If, as stated at the beginning, food security ought to be a top priority for development cooperation at the energy and food nexus, and SSA a prime target area therein, what are the figures that could support such a claim? According to the United Nations' World Food Programme (WFP), only 27% of malnourished people worldwide live in Africa; but in contrast to their fellow sufferers in India and South Asia, most Africans cannot fall back upon prosperous and relatively well-developed nation states to help them in their plight. 80% of those starving live in rural areas, and about half of these are subsistence-bound smallholders. A very high portion (up to 90%) of energy used in Africa still comes from traditional sources, particularly fuelwood, and most of it serves only consumption purposes, and not production. There is a broad consensus in development cooperation and research nowadays that wood-based energy demand in Africa will increase rather than decrease in the future. The current low and insufficient technology and input regime translates into poor utilisation of fertilisers (8 to 10 kg per hectare, as opposed to 150 in Asia, according to the World Banks's 2008 World Development Report) and mechanization: 80% of cultivation in Africa is still carried out by hand, with only 1.2 tractors per 1000 ha agricultural land, says FAO. And these figures have indeed plummeted from much higher levels in the past! In sum, there is clearly a massive shortage of affordable, readily available energy in Africa, and energy use, particularly in SSA, must increase significantly if food security is to be achieved in the long run. Most energy sources,

however, also produce greenhouse gas (GHG) emissions and contribute to climate change, which is in itself a major threat to food security, again particularly in SSA. The ecological footprint of Africa's agriculture is in fact not small (actually larger than that of the EU), but given the continent's sizeable population, the overall emissions per person and year are less than 0.2 t CO2 equivalent (as opposed to 10 in Germany, for example). While there are options to mitigate increase of GHG emissions as productivity and yields expand in agriculture, there remains a fundamental challenge for development cooperation in balancing environmental targets (including mitigation) against productivity targets. The ultimate preference, though, should be apparent:

Food security in poor countries, aided by more energy inputs if needed, must come before energy savings and reductions in greenhouse gas emissions.

Substantial increases in the latter are but inevitable in this scenario, and the U.S. Environmental Protection Agency (USEPA), for instance, rightly expects a rise of 30% in African GHG emissions between 2010 and 2030. Given that a multitude of complex relations exist between energy use and food security issues, it is extremely difficult to make scientifically grounded recommendations concerning priorities of energy use in SSA agriculture and food systems. Additional concerns that would have to be taken into account in such recommendations are the costs, cost effectiveness and likelihood of success of any given measure. Thus, the following four foci are somewhat arbitrary and reflect the author's subjective assessment only.

Focus 1: Draught animals and mechanisation

One strategic energy intervention aimed at enhancing food security in Africa is the introduction of draught animals and heightened mechanization. Both entail multiple effects on several agricultural value chains and beyond. The most obvious results are increased tillage and higher yields due to deeper and more timely soil preparation. In the case of Benin and its cotton plantations, for example, the introduction of oxen helped expand the land under cultivation by 25 to 50%, while harvests grew by 10 to 30% and incomes by 40 to 70%, both for cotton and for food crops. This contributed to increased food availability and income not only for farmers, but also for consumers. In addition, draught animals act as triggers of virtuous cycles in soil fertility management. Once crop cultivation and animal husbandry have been brought together – a pairing which in Africa is rare, for ethnic as well as geographical and animal-health reasons – and animals are kept in higher numbers on a permanent basis, soil fertility can be improved thanks to animal manure and the introduction of fodder production into farming systems. Fodder legumes enable nitrogen fixing in the soil and boost yields, which can increase and stabilise the output of an entire farming system. A complimentary effect of animal traction is increased on-farm transport of organic material (manure, residues) between fields and farmstead. Animals can be used for threshing and further on-farm mechanisation. They render smallholders more independent of traders, reduce transport costs and increase income, as crops can now be transported to the market place and sold there directly by farmers. Being tradable goods themselves, draught animals may also function as savings banks, which increases resilience in times of hardship. Meat and milk production improve smallholders' diets. Equipment can be rented out to other famers and so contribute to enhancing production and transport, even beyond the immediate scope of a single farm. All in all, an entire secondary supply industry may spring up from mechanized, animal-drawn agriculture: blacksmiths, transport services and animal markets.

Several of the above effects may also be observed for mechanisation with motor vehicles. However, synergies are much less visible here, in particular with regard to soil fertility. Motorisation is expensive and less flexible; it requires external energy supply and increasingly sophisticated maintenance. On the other hand, purchasing and managing basic mechanical tools may be easier to accomplish in social terms than integrating animals into an existing farming and livelihood system; also, the services of local entrepreneurs may be enlisted for the cause. Both paths to mechanisation, however, have a rather dubious implementation record, featuring a long list of failed attempts at introduction. Very often, mechanisation is feasible only where a substantial cash-crop production already exists – a production capable of generating the incentives and revenues necessary for the comparatively high investments for machines and equipment to pay off.

Focus 2: Sustainable charcoal value chains

Using charcoal instead of fuelwood, and putting charcoal production on a more sustainable footing, provides many opportunities for improving food security. Charcoal has significant economic dimensions in many SSA countries: in Malawi, 6% of all energy, including industry and transport, 2% of all jobs and 11% of the expenses of the poor urban populace are related directly to the charcoal value chain. In many other SSA countries, the charcoal sub-sector is similarly large. In contrast to its importance, however, it often remains hidden, mainly because charring is an informal,

frequently forbidden activity due to its negative environmental effects when done in an uncontrolled manner. Production often thrives nonetheless as affordable alternatives are lacking.

There are many steps and areas in the charcoal value chain that can be improved with a view to making operations less detrimental – from sustainable forest production and better charcoal technology and handling, to reduction of marketing costs through legalisation of (sustainable) charcoal. Cooking stoves that use charcoal can be improved too, but most 'modern' cooking stoves in these countries use charcoal anyway. Burning charcoal is a much cleaner process than burning wood, so improved health as well as reduced costs are the most concrete effects of interventions that aim at improving (and legalising) the charcoal value chain. Increased production of charcoal will however also raise incomes in processing and marketing, as it creates simple and accessible employment for charcoal burners, traders and carriers. Less expensive, readily available charcoal likewise lowers costs for the production of other agricultural and consumer goods that require heat processing. Effects on rural development in a broader sense can be manifold, though not all of them are easy to control or manage: sustainable forest production and agro-forestry systems may be expanded, but only if the legalisation of improved charcoal is accompanied by stricter control and measures against non-sustainable practices. There are examples, e.g. from Madagascar, where the land rights situation of poor populations has been boosted by promoting participatory tree-for-charcoal plantations, and where local communities profited financially from such endeavours through taxes and fees for certification. Good governance, in any case, is key to improving charcoal value chains without harming the environment.

Focus 3: Biofuels

A third possible focus for interventions, still relating to energy sources in the agricultural production process, is modern (liquid) biofuels. Although this is an extremely contested issue, it is argued here that there exist value-chain arrangements at the local level that allow for sustainable production of biofuels in developing countries, and thus may help in improving food security. A prominent example, and possibly the only one with a long-term track record, is bioethanol production from molasses (a byproduct of sugar production from sugarcane) in Malawi. Promoting sugarcane cultivation for production of sugar and ethanol in the Southeast African country saw incomes of contract farmers soar by 130% and created additional jobs for plantation workers. Poverty was drastically reduced for both professional groups as a result. However, despite its potential positive effects on incomes and employment, the cultivation of biofuels may also entail less advantageous developments: biofuel production can displace food crops (even entire farms), or lead to conflicts over the distribution of the capital and income it creates. Rural development, on the other hand, is likely to receive a boost from the pull towards biofuel production at a larger scale: villages often grow into rural centres in areas of biofuel production, and the extra energy available for transport and production and processing can trigger a whole array of positive secondary effects on product quality, prices and stability of supply.

Focus 4: Advancing the 'modern electrical energy frontier'

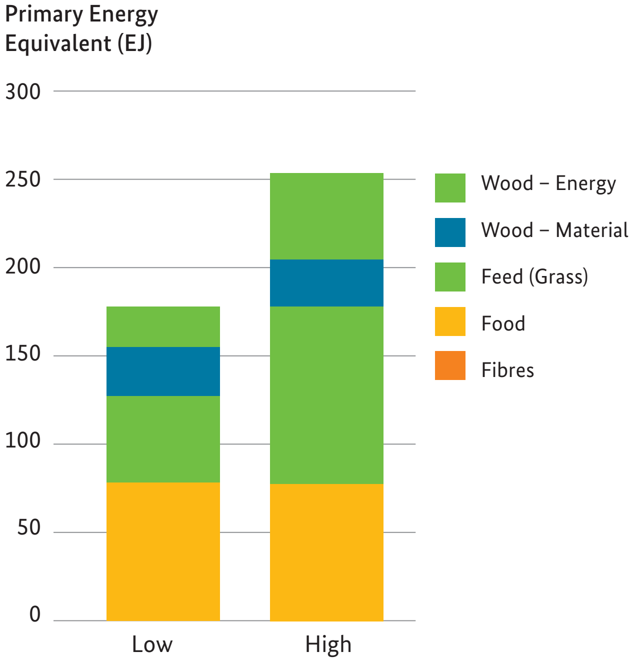
Expanding electricity networks and access to electrical energy has long been a mainstay in development efforts, particularly in Africa. Yet, the World Bank estimates that only 12% of the rural population south of the Sahara currently has access to electricity. Cheap electrical power and its efficient use are however a prerequisite for economical agricultural production, as well as for competitiveness overall. Resources are plentiful in many rural areas, and renewable energies may very well be harnessed for electricity supply – to the point where rural economies powered by biomass plants and solar installations could become the vanguard of a new energy frontier. This would in fact create a novel situation, unprecedented in our post-industrialisation world, in which abundant and cheap renewable energy would become an asset and comparative edge for rural areas vying for attention and investments with the urban sprawl. However, for this to happen in Africa, one must not resort to high-end technology imports but rather adapt existing intermediary technologies that rural populations are already able to handle. The main challenge for enhancing food security through energy development interventions in agricultural value chains consists in building local support systems and advisory services for financing, applied research and business cooperation. While the international private sector has to play a part in this, it is more important to partner up with local enterprises, procuring adequate technology from where it is available. The 'developed South', for example, may still be familiar with technologies and agricultural practices that have fallen into disuse in the North. What is needed for successful energy politics and development in the context of food security are 'peasant-public-private partnerships', centred around local conditions and needs, and catered for by local agents. Northern know-how and technology is a plus, but should not be considered indispensable!

(Bio-)Energy for Sustainable Food Systems

Uwe R. Fritsche, *Scientific Director, International Institute for Sustainability Analysis and Strategy (IINAS)*

Global primary energy consumption currently hovers at about 500 EJ (IPPC 2011), the vast majority of which is provided by fossil fuels. Of the 14% that can be attributed to renewables, more than 70%, or 50 EJ, derives from biomass sources. However, only 20% of this segment qualifies as 'modern' bioenergy – that is, electricity, heating energy and transport fuels directly derived from biogenic materials in sophisticated technological processes – while the other 80% still comes from traditional sources and uses, primarily fuelwood cooking and heating. Thus, beyond the substitution effects that renewables are thought to provide on a general level, one point of critical attention must always be the nature of these services. Sustainable and eco-friendly biomass can be produced from wastes and residuals of agricultural production processes, from degraded areas, as well as from arable land or grassland whose marginal revenues have sunk below a profitable level or that for other reasons (legislative, environmental, demographic) have been taken out of cultivation. This 'sustainable' bioenergy has the potential to contribute between 200 and 500 EJ to a global demand that, even in the most optimistic of IEA scenarios, is expected to climb to 700 EJ by 2050.

Biomass expressed in Energy Equivalents



Source: IINAS, EFI, JR (2014); all biomass expressed in energy equivalents based on LHV; data for global supply 2008–2010

Global energy tomorrow: Bioenergy shares and potentials

If biomass is indeed to add significantly to future energy supply, it is important to identify and localise its sources within existing material flows and production cycles. One major source is agriculture proper, which includes not only crops specifically cultivated for the purpose of energy and fuel production, but also harvest residues and cuttings, as well as biogas, which may be used to the same effect. Alternatively, there is forestry, with biomass extracted in the form of fuelwood and lumber. In both cases, however, complete biomass removal is often not an option, as soil fertility or erosion protection may demand that a certain amount of biogenic materials remain at the source site. Instead, more attention should be placed on the later stages of agriculture and forestry value chains. With the arrival of a bioeconomy that largely relies on biomass for energy and material, we are likely to see a surge in wastes and residues in the processing industries; these could then be fed into furnaces and fermenters as an additional source of energy. What should be apparent is that none of the uses indicated can claim precedence over any others – not energy over food, energy crops over residues, or nature conservation over security of supply. In the end, a balance needs to be found between bioenergy potentials, demand, and inherent constraints.

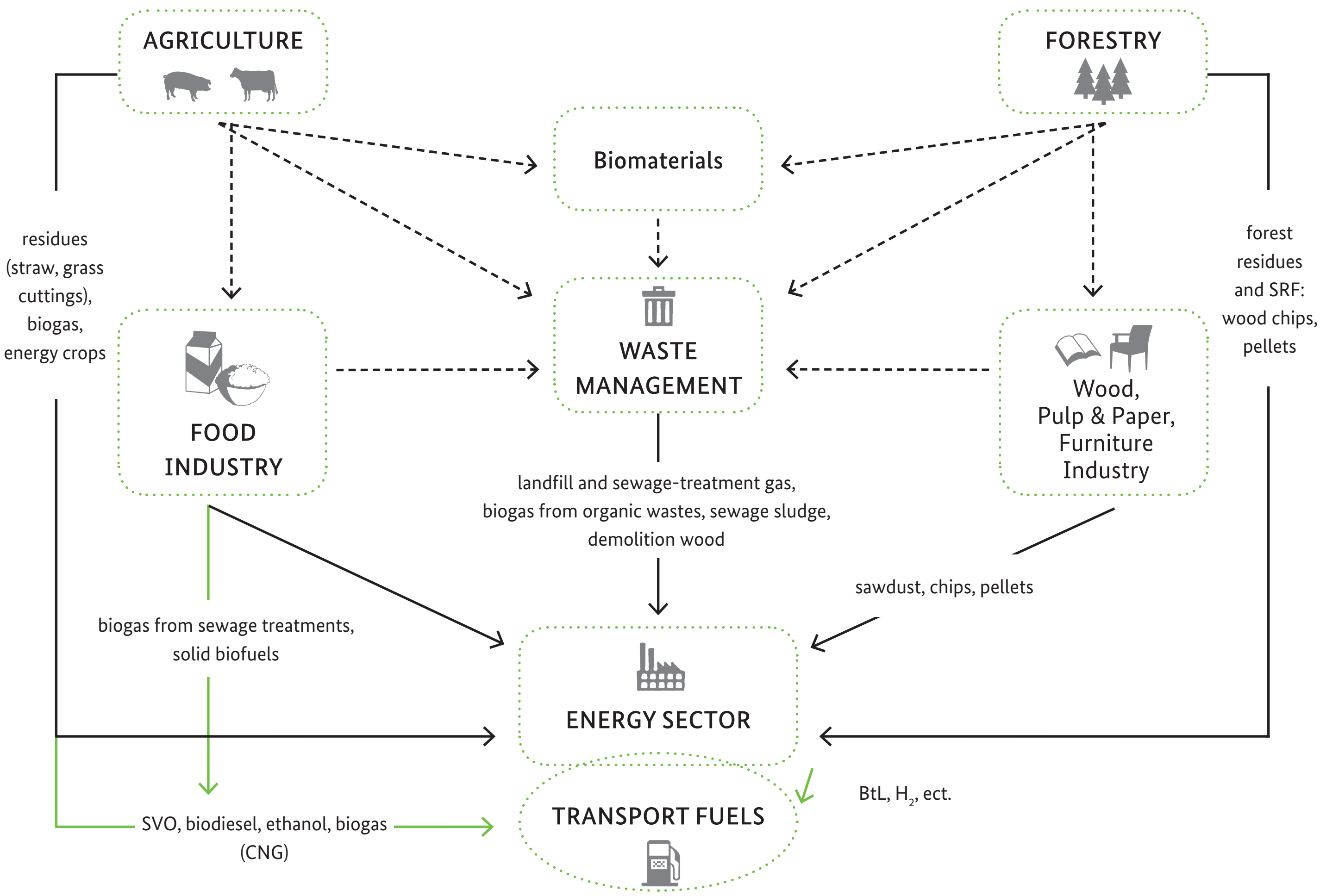
Biomass:
Food, feed, fibre, fuels

In most debates weighing the competing uses of biomass against each other, scientists (and politicians in their wake) are generally quick to revert to land use as a basis for argument: how much land is allocated for production of bioenergy? How much is used for biomaterials? And how much, ultimately, for food? Yet, there exists another, more differentiated approach to assess the situation, which is to compare biomass uses on the basis of the primary (heat) energy equivalent they each represent. Displayed in this way, it becomes obvious that marketable 'food' destined for human and livestock consumption, though it constitutes a substantial part of biomass production, is rivalled, and even surpassed in some scenarios, by a much more elastic 'feed' band, which reflects what enters the food system naturally through the grazing of livestock. Figures here are indeed in striking agreement with land-use reality: about 70% of farmland is currently used for agricultural products that at some stage involve husbandry. The contribution of biomass (wood) for use as energy or material pales in comparison. Notwithstanding the mode of calculation, the conclusion remains the same: raising the share of fuel (direct energy) derived from biomass will inevitably impinge on its other energetic uses, on food, feed and fibre – unless, that is, one manages to raise productivity in all spheres of production.

Bioenergy opportunities:
Resource efficiency and ecological benefits

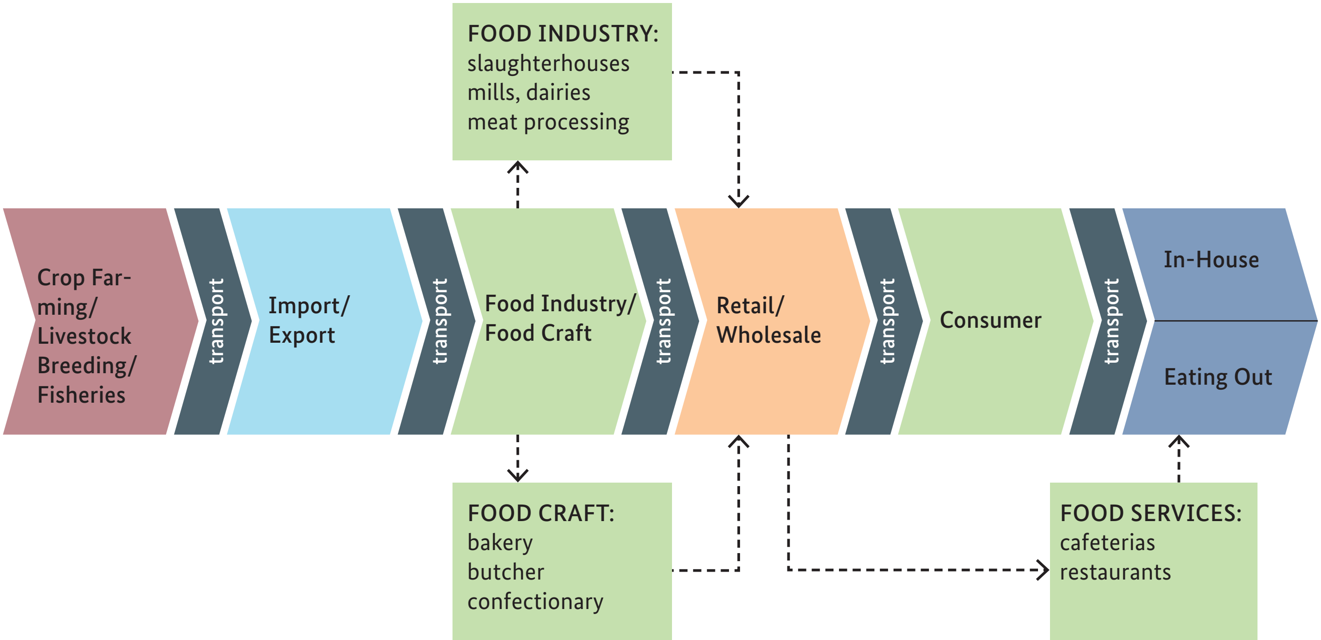
Massive intensification or displacement are the two axes that have dominated debate so far, yet bioenergy offers a host of other opportunities that lie just in the space between. Accepting the need for production expansion, but also the limitedness of natural resources, scientists have introduced the concept of 'cascading'. It holds that biomass should be produced primarily for material purposes, and

Biomass Sources for Use in Bionenergy Production



Identifying sustainable bioenergy potentials: All biomass flows need to be considered

EUPOPP Food Value Chains: ‘From Field to Fork’



European Policies to Promote Sustainable Consumption Patterns (EUPOPP)

its energy content only be recovered (through burning of residues and wastes) after all material has served at least one cycle of production. The gains in resource efficiency in this scenario are obvious. Yet even if one embraces increased biomass cultivation solely for the purpose of energy recovery, there are plenty of benefits to be reaped: new biomass systems, such as short-rotation plantations or energy grasses, may enrich biodiversity and break the monotony of agricultural landscapes, establishing corridors for animal migration or acting as vegetational buffers against erosion. Bioenergy cultivation may also improve regional water management and thus secure important ecosystem functions, particularly in semi-arid regions. Energy crops tend to be more drought-tolerant than agricultural crops, and perennials – energy woods or grasses – may improve water retention in the soil.

Bioenergy opportunities: Palpable economic profits and effects on food security

Benefits, however, transcend the purely ecological. Residues from landscape or habitat management may become an additional source of revenue if used for bioenergy production – such as in the case of nature reserves, where, for conservation reasons, it is often necessary to withdraw biomass on a continual basis (German example: www.lpv.de). Economic benefits, moreover, multiply in the context of developing countries. In sub-Saharan Africa, access to modern bioenergy promises to boost rural development by reducing deforestation pressure and mitigating urban migration through extra income and employment. Food security is another factor potentially enhanced by bioenergy cultivation. Intercropping and perennial crops on low-carbon and degraded soils can improve carbon balance and help restore arable land, which works to alleviate land competition between ‘fuel and food’ in the long run. Successful examples of biofuel integration on larger scales already exist. For example, in Sierra Leone, the British company Addax, aided by an array of multilateral donors, is now producing – in a sustainable and exemplary manner – ethanol from sugarcane on its plantations. The Addax experience could be mainstreamed within Sierra Leone shortly, as Germany (through FAO) has started an implementation project for the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT).

EUPOPP Project: Sustainable Food

Turning away from questions of supply and focusing on consumption issues instead, one is baffled to find that large-scale analyses of the links between energy and food, especially with regard to agricultural value chains, are rare, at least for developing countries. For Europe and the

(Bio-)Energy for Sustainable Food Systems: Uwe R. Fritsche delivering his talk at the symposium

developed world, the lacuna may have been filled by the EC research project 'European Policies to Promote Sustainable Consumption Patterns' (EUPOPP), carried out by a consortium of seven partners from five different EU countries (Finland, Germany, Latvia, Spain and the UK) over three years, from 2008 to 2011 (www.eupopp.net). Among other themes, the project examined food value chains, with an explicit focus on Europe's highly efficient, industrialised agricultural landscape, spanning the entire chain from 'field to fork', from rural production to urban consumption. What it found was that 90% of energy consumed – and an even higher percentage of greenhouse gas emissions – results not from production but from processing, transport and distribution. It is here that efficiency measures can work to greatest effect, and that wastes and residues may be tapped for supplementary energy services. All data on material flows, emission impacts and employment are available from GEMIS, a free public database and calculation model by IINAS; they may serve as benchmark values for further research, also in developing countries (www.iinas.org/gemis-de.html).

In lieu of a conclusion: A plea to decision-makers and donors

The upcoming international discussion on a 'bioeconomy' – that is, an economy increasingly dependent on biomass, in all its forms and uses as food, feed, fibre and fuel – must reflect that the key issue in sustainable supply is *not* a supposed antagonism between food and fuel, as debate would have it, but one of land use. Using biogenic wastes and residues for bioenergy production (through cascading) is fundamental to reducing land pressure and competition in the case of *both* food and fuel creation. Nevertheless, biodiversity limits – for example on material extraction from fields and forests – and soil carbon changes must also be considered. Bioenergy can be used to put marginal and degraded lands back into production (and thereby create value) but biodiversity and social safeguards must also be put in place. 'Green walls', with their double function of fighting desertification and providing fuelwood, are a good example in this respect. They offer an effective base for agroforestry practices, and as long-term, stable sources of income and employment, they promise to enhance food security as well. However, land rehabilitation through biomass, as in the case of green walls, as well as for degradable land in general, requires strategic investment and steering if its benefits are to reach the local populace. Integrated agro-energy-water and forest-energy projects are needed to deliver synergy effects, and to help mainstream what has proven locally successful. The market alone will *not* suffice!

Bioenergy can – and in many regions must – be part of sustainable food systems!

Technology Management and Innovation in Regional Energy Supply

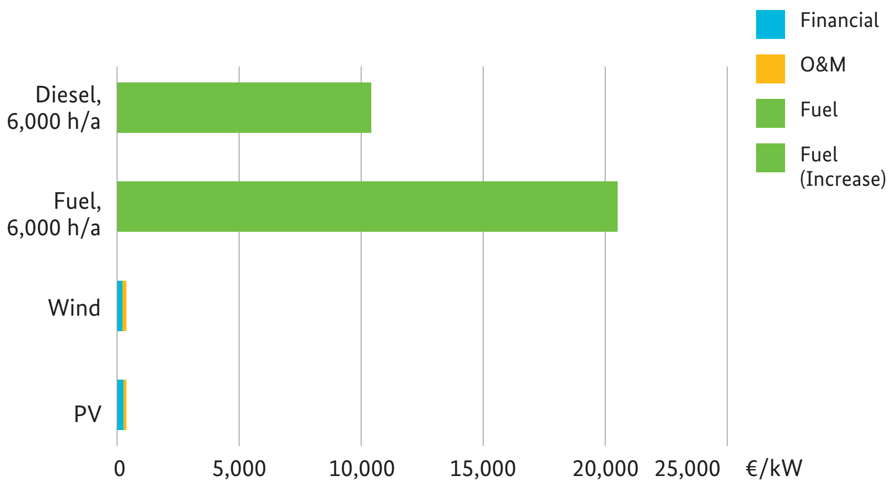
***Prof. Dr Peter Heck**, Managing Director, Institute for Applied Material Flow Management (IfaS)*

Material flow management (MFM), as it is practiced by IfaS and other specialist institutes around the world, proceeds from the assumption that energy and material systems are very inefficient, but nevertheless harbour a great potential for efficiency measures if dissected and reorganised according to the principles of 'circular' economics and sustainable development. In the context of energy and agriculture, this basic assumption leads to a project set-up wherein energy expenditures for planting, irrigation, growing, harvesting, processing, storing, transport, sales and disposal are scrutinised in a first step, followed by a second critical project phase during which potentials are identified with regard to energy efficiency, renewable energy sources, waste-to-energy, or wastewater-to-energy, as well as 'embedded energies', such as they occur in the form of fertilisers and agrochemicals, or in buildings. Applied in this comprehensive manner, the MFM approach produces impressive results. In a zero-emissions scenario calculated for the Rhein-Hunsrück county of the German federal state of Rhineland-Palatinate, for example, IfaS computed a total added value of 800% in energy-related services if the county continued to expand its utilisation of renewable electricity and heat, which would make it a net exporter of green power in the long run. The same applies to bioenergy in Morocco: an IfaS-scripted master plan for regional energy supply here discerned a biomass potential of 10,000 toe that would be readily available if the right technologies and financing instruments were chosen.

Cape Verde: Renewable energy as an option for the future

Following a cabinet order that called for a complete makeover of the country's energy sector by 2020, IfaS was commissioned by the government of Cape Verde to develop a 100% renewable-energy scenario for the island state. The

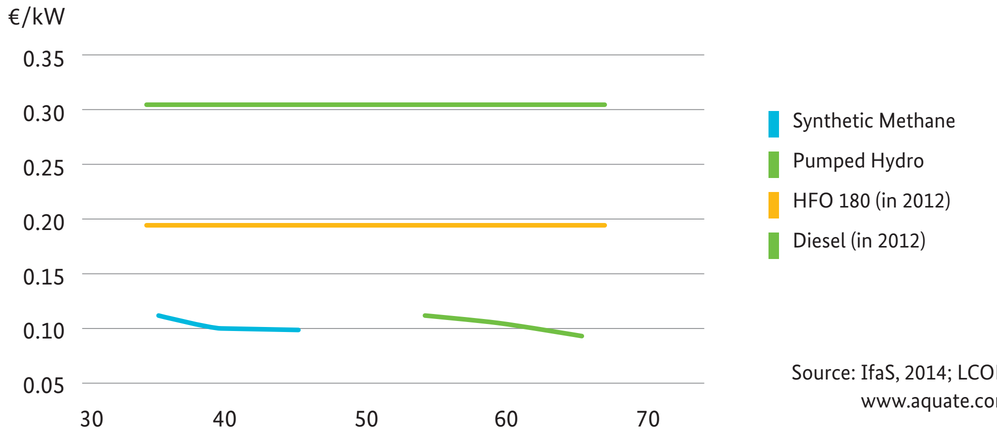
Annual Energy Cost Over Lifecycle (Cape Verde)



Assumptions	
PV	3,400 €/kWv
Wind	2,200 €/kW
Thermal Group	1,000 €/kW
Efficiency	30%
Fuel Cost (act.)	0.71 €/lv
Diesel Cost	1.09 €/l
Increase rate	15%/a
	8.5%/a
Service Time	6,000 h/a
Life Cycle	20 a

Clear advantage of renewables: Lifecycle costs (general) and LCOE (scenarios) of selected energy types

Levelised Cost of Energy related to Production (Sal, Cape Verde)

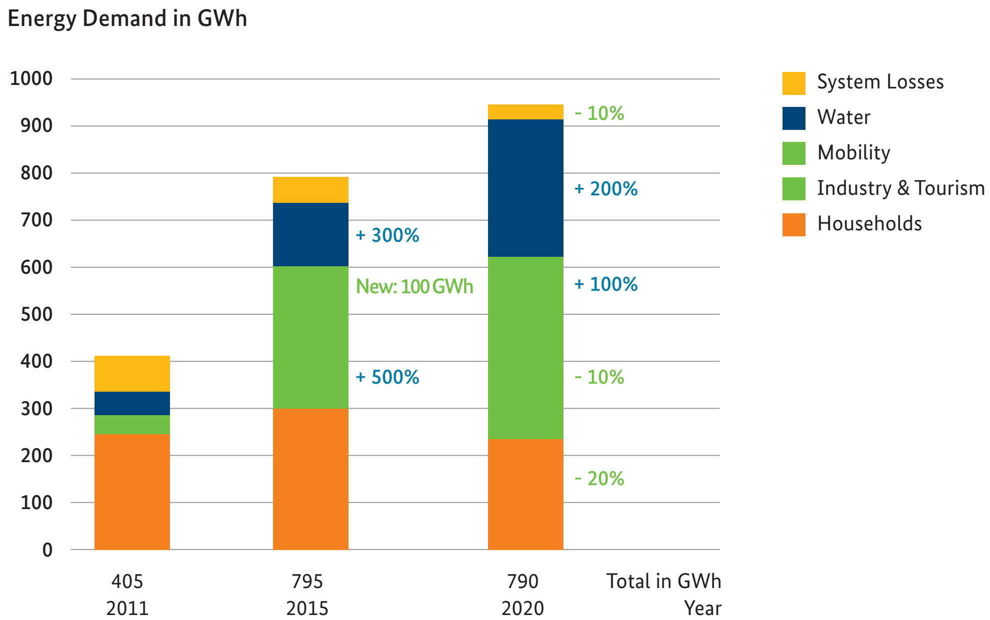


Source: IfaS, 2014; LCOE related to total production
www.aquate.com | IfaS, 2014

government's decision was by no means a rash one: the Cape Verdean economy is currently handicapped by a very disadvantageous energy regime. Geographically isolated and with no oil reserves to speak of, it is heavily dependent on fossil-fuel imports, mainly diesel and heavy-fuel oils (HFO) for use in generators. These imports drive up electricity prices – currently at 0.35 €/kWh – and render energy-intensive operations almost impossible. Agriculture, moreover, is hindered by water scarcity, with expensive water imports adding to farmers' bills. Making the switch to 100% renewables under these conditions promises immediate relief: electricity prices would fall significantly, as renewable energies like wind or solar power only require an initial capital investment, but eventually operate at almost zero cost, so their lifecycle and levelised costs are extremely low in comparison to fossil fuels. Of course, producing cheap, clean energy in their own backyard would also free Cape Verde from dependence on imports and spiralling international oil prices.

As highly intermittent sources of energy, however, renewable energies always require an installed capacity equal to peak demand, which makes for a substantial amount of excess energy during periods of baseload – up to 600%, or 2,500 MW worth of electrical power, in the IfaS scenario. This excess energy, while representing an operational difficulty in other contexts, would in effect be an asset for

300% Scenario: Development of Energy Demand by Sectors (Sal, Cape Verde)



Equivalent Energy Services/Products Derived From Excess Energy

SCENARIO	Total Investment* (million EUR)	e-Mobility (million km)	Cooking Gas (cylinders)	Desalinated Water (million m^3)
SCENARIO 1 (68% over-supply)	162	234,000	149,000	14.6
SCENARIO 2 (48% over-supply)	125	165,000	105,000	10.3

*Investment for power generation and storage infrastructure includes solar PV, wind converters, battery and seasonal storage

Cape Verde: if used directly for desalination – the process of converting saltwater into freshwater – it could help put additional arable land into cultivation and increase agricultural production on the dry archipelago. The energy could also be used in part for deep freezing and thus put an end to the massive storage problem that plagues Cape Verdean fishery and horticulture. The country's fishing fleet currently delivers its entire catch to the Canary Islands because electricity is too expensive to make fish storage and processing profitable at home. In the end, then, a targeted renewables strategy would not only be a boon for Cape Verdean energy supply, but also, and more importantly, would revolutionise the island's agriculture and food sectors.

Case study: Sal, Cape Verde

One of the archipelago's largest islands – and, incidentally, its main tourist destination – may serve as a good illustration of the potentials a thorough MFM analysis can reveal. Extrapolating from current energy consumption patterns, the scientists at IfaS were able to forecast that the island of Sal's energy demand would reach 86 GWh/a in the year 2020. This figure was then set against an estimated potential renewables supply of either 145 or 127 GWh/a, with the amount dependent on the specific energy source harnessed – pumped hydro in the former case, synthetic methane in the latter. The significant surplus that would result from either type of energy (68% or 48%, respectively) could be used to power energy services and production operations that either do not exist currently or are performed to a much lesser extent under today's high-price regime: seawater desalination to begin with, but also e-mobility, or production of cooking gas for home use. The values thus calculated offer new possibilities for political planning, too. Since the release of the IfaS study, Cape Verde's national development plan has seen multiple revisions, as cheap energy from renewables now allows the government to define larger energy quotas for all economic sectors. It is already clear to everyone involved that a 100% renewables system will expand cultivable land and enhance food

Cultivation of High-Value Crops Under Greenhouse Conditions (Sal, Cape Verde)

	Tomato	Cucumbers	Capsicum	Lettuce	Total
Cultivated Area (ha)	10	10	10	10	40
Water Demand (m^3/a)*	182,500	146,000	127,750	75,000	531,250
Elec. Demand Cultivation (kWh/a)**	55,275	49,875	49,875	134,555	289,580
Elect. Demand RO (kWh/a)**	1,003,750	803,000	702,625	412,500	2,921,875
Harvest (t)	2,500	2,200	1,080	3,000 t-piece	
Economic Result (€/a)	416,156	-225,389	-5,420	563,953	749,299

*Water TOTAL: 531,250 m^3/a (~5% of the water over-supply!) **Energy TOTAL: 3.2 GWh/a (~8% of the energy over-supply!)

Source: www.aquate.com

security – a serious issue in a country historically beset by droughts and famines. And what is more, the gains can even be quantified: IfaS calculated that by directing RE-desalinated water towards the irrigation of land, including greenhouses, a profit would result of almost €800,000 per annum for a set of high-value crops, whose cultivation had not been possible on a dry, unirrigated island of Sal.

Case study: COPAG, Morocco

Project idea

- → Planning and construction of a biogas plant for agricultural cooperation COPAG, with the aim of providing sustainable energy through valoristion of organic reisdues

Objectives

- → Production of renewable energy (electricity, heat) out of different organic materials and organic residues
- → Use of energy from plant for production processes (juice production, milk factory, slaughterhouse, etc.)
- → Production of high-quality soil conditioner for local farmers

Elaboration

- → Feasibility study for construction of agricultural biogas plant to provide energy directly at production site

Long-term goals

- → Improvement of decentralised energy supply in rural areas through valorisation of agricultural residues
- → Production of fertilisers through use of digestate from biogas plant

While Cape Verde proved a challenge to the IfaS team, both in terms of the complexity of calculations required as well as a local hesitance towards renewables, the construction of a biogas plant for Moroccan agricultural cooperative COPAG was a fairly easy task in comparison. Framework conditions, however, were similar. Like Cape Verde, Morocco is faced with soaring energy prices – and these in fact have a doubly negative impact on the government's bottom line, as petroleum products are subsidised to keep them affordable for the largest portion of the population. There is a keen political interest, therefore, to increase the share of renewables. Likewise, ambitious targets have been declared for agriculture. But here, too, water scarcity puts a damper on significant growth. Groundwater levels are falling under irrigation pressure, so the Moroccan government, like its Cape Verdean counterpart, is turning towards excess renewable energy for seawater desalination. The IfaS study was carried out against this backdrop and, indeed, provided promising results: a biogas plant, running on process waste and manure, would have an internal rate of return as high as 15% if placed at an optimum location with optimum grid integration and supplying energy on-site. This obviously raises a fundamental question: if they are so economically attractive, and ecologically desirable, why aren't renewable-energy plants springing up all over countries like Morocco and Cape Verde?

Lessons learned: Obstacles to implementation of MFM-based energy scenarios

One major problem, it seems, is financing. In Morocco, projects with shorter amortisation spans and higher returns on equity investments, such as in real estate, lure investors away from the renewables market. As mentioned earlier, renewable energy installations generally have high upfront capital cost but low maintenance, so they require long-term credit at low interest, both of which are not likely to draw capital under normal market conditions. Action from public investors and development banks such as KfW and the World Bank is needed to get such projects off the ground. Another problem, also closely tied to financing, is participation. Renewable energy has up to now been brought into portfolios of developing nations most often through power purchasing agreements (PPAs), contracted with project developers from overseas, who offer all-inclusive packages – financing, installation, operation and supply, on-site or transmitted from afar – against relatively high-priced electricity, charged per kWh and paid in foreign currency. This certainly greens an energy portfolio, but it does not create local ownership or local added value, and it ultimately drains local resources. In response, the Cape Verdean finance minister has taken a firm stand against such agreements and now lobbies, among other things, for the country's retirement fund to invest at home instead of seeking returns abroad. The bill to be footed is immense by any standard: 100% renewables in Cape Verde comes at a cost of €1 billion.

Committed support from politicians at the top, unfortunately, does not guarantee support from all political or economic stakeholders either. Changes in existing systems, particularly where they affect highly lucrative businesses like energy and oil imports, create both winners and losers, and the latter need to be compensated if they are not to evolve into disgruntled opponents of the proposed changes. Again, Cape Verde is setting a good example in this respect. The government there decided to revamp its

Technology Management and Innovation in Regional Energy Supply: Prof. Dr Peter Heck delivering his talk at the symposium

neglected major utility, Electra, with the sole purpose of creating new positions for those who would find themselves pushed out of business (and/or power) as a result of the switch to 100% renewables. It is indeed important in stakeholder management to inform interested parties about changes well in advance and flag up alternatives, so as to nip fear and frustration in the bud. Renewable energies are a blessing in this regard, as they offer secure and permanent rents once the initial investment has been shouldered – rents that can be distributed among those seeking compensation. A clear view of the future is also needed in capacity building. All too often ambitious training programmes are developed without regard to political realities, and donor countries are as guilty of negligence here as the governments of developing countries that send their people away for training but cannot offer jobs when they return. The Cape Verdean government explicitly asked IfaS to develop an education policy alongside their scenario in order to make sure technological and economic implementation was well matched with human resources.

Case study: Agro-industry in Sri Lanka

Sri Lanka provides another example of applied renewable energy technology and how it can be harnessed in agriculture not only to deliver energy for operations, but also to measurably enhance food production. Through a combined pyrolysis cycle, producing heat as well as biochar, IfaS was able to offer local cooperatives a means of reviving their leached, exhausted soils, while avoiding further input of expensive chemical fertilisers. Instead of those, 2,500 t of biochar per annum would now be broadcast on the cooperatives' land, itself produced from 10,000 t/a of biogenic wastes from the coconut industry, in a process expected to yield an additional 8.8 GWh/a of heat energy. With a total market value of €1.25 to 2.5 million, the char could moreover be sold profitably as active coal to industry and thus contribute to refinancing the installation and running of the pyrolysis plant. A similar combined process of heat and fertiliser production, though with pure phosphate as the end product, could be conducted with sewage sludge as well. For both applications, a main thrust is the idea of working in closed loops and developing local resources as a substitute for imported embedded energies. Seen from this angle, pyrolysis of agricultural wastes on a single-plant level is as important a step towards economic independence and sustainable development as is the makeover of an entire energy sector. Both are valid contributions to development cooperation, and both warrant implementation.

Reorganising the Energy Industry and Supporting the Food Industry

The LEADER Region Sauerland as a Case Study in Regional Development

***Stefan Pletziger**, Regional Manager, 4 mitten im Sauerland ‘4 in the Middle of the Sauerland’*

Everyone who works within the energy and food nexus is driven by the same question: how do we produce more food using as little energy as possible, while also increasing the share of renewable energy? One need not go as far as sub-Saharan Africa, however, to find answers. Indeed, sometimes one need only look as far as one’s own backyard. Even if that backyard is found to be set securely within the German countryside, far-removed from problems of chronic and perennial hunger. The four municipalities of Bestwig, Eslohe, Meschede and Schmallenberg in the Hochsauerlandkreis (‘Higher Sauerland District’) of the German federal state of North Rhine-Westphalia are one such area that could provide valuable insights into how to line up energy demand and food production in a more sustainable manner. Together, they form the LEADER region ‘4 in the Middle of the Sauerland’, which is funded as one of 255 regions in Germany by the European Union programme of the same name.

The LEADER programme

LEADER is an acronym in French for Liaison entre actions de développement de l’économie rurale (‘Links between actions for the development of the rural economy’), and as such aptly captures the programme’s scope of application. LEADER offers support to rural development projects initiated at the local level in order to revitalise rural areas and create local jobs and value. One of its principles is a strict bottom-up approach, which specifically asks soliciting parties to get together in local action groups and develop jointly what they are to propose for funding. Programme managers are dispatched to help with EU formalities and give advice on project layout and implementation. If judged to have good potential, projects can be funded up to 55% by LEADER. Though budgets are comparatively small, varying between €10,000 and €30,000 in size, the emphasis placed on local, concerted action creates a strong sense of solidarity and ownership among participants.

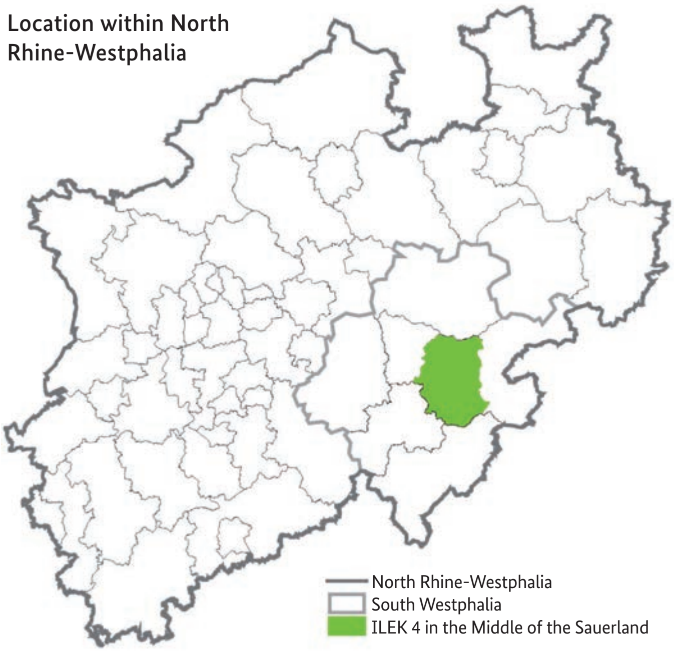
Renewable energies in Hochsauerlandlkreis

The Hochsauerlandkreis currently shows an impressive 40% of electricity supplied by renewables and financed under the German Renewable Energy Act (EEG), of a total consumption amounting to 2,060,389 MWh per annum. Most of this electricity originates from PV systems, followed by wind turbines and, in third place, biomass plants; all other types of renewable energy, such as water or geothermal power, are at present negligible. Notwithstanding the latest EEG amendment, which instituted a cap of 100 MW on annual capacity expansion for biomass and significantly reduced feed-in tariffs within this domain, biomass is the only renewables technology to date that can generate dependable power to meet base-load requirements. It is thus certain to play an increasingly important role in the energy supply of the future. Of course, it is also the technology featuring the greatest critical overlap with food production. At present, only 31% of land surface in the Sauerland is used for agricultural purposes, while 58% is covered by forests. Agricultural lands, moreover, are for the most part grasslands, as dairy farming continues to dominate in this region.

The village of Ebbingdorf as an example for closed renewable energy systems

Ebbingdorf, a municipality within the Schmallenberg jurisdiction, was the first village in North Rhine-Westphalia to be fully powered by renewable energy sources and, in turn, to receive the honorary title of ‘bioenergy village’ in recognition of this achievement. Just as the name suggests, it runs largely on biomass, fermented and combusted in a lo-

LEADER Region ‘4 in the Middle of the Saurland’



Characteristics in Brief

Total Population:	ca. 84,300
Total Area:	ca. 704 km^2
Population Density:	ca. 120/km^2
Land Use:	58% Forest, 31% Agriculture, 11% Settlement and Transportation
Natural Environment:	Higher Sauerland/Bergisch-Sauerland Mountain Range
Towns:	Meschede, Schmallenberg

cal biogas plant. Electricity and heat production nowadays are sufficient not only to provide for residential buildings, stables and a hotel in the village, but also to supply heat to the neighbouring town of Schmallenberg and its municipal facilities, through a locally distributed heating network. Thus, the energy derived from agricultural products and within the agricultural value chain transcends the borders of agriculture proper here; it is used directly for commercial purposes. The biogas plant runs at full-load during 8,400 hours per year and produces 9.2 million kWh of electricity and 10.4 million kWh of heat, with only a minuscule portion needed for its own operation. For this, 9,000 m^3 of cattle and pig slurry, about 10,000 t of manure from cattle, horse and poultry farming, as well as 10,000 t of maize silage and 4,000 t grass-cuttings are fed into the plant’s fermenters. Peak demand is secured through a combined heat and power station running on woodchips, which has been integrated into the closed-loop system.

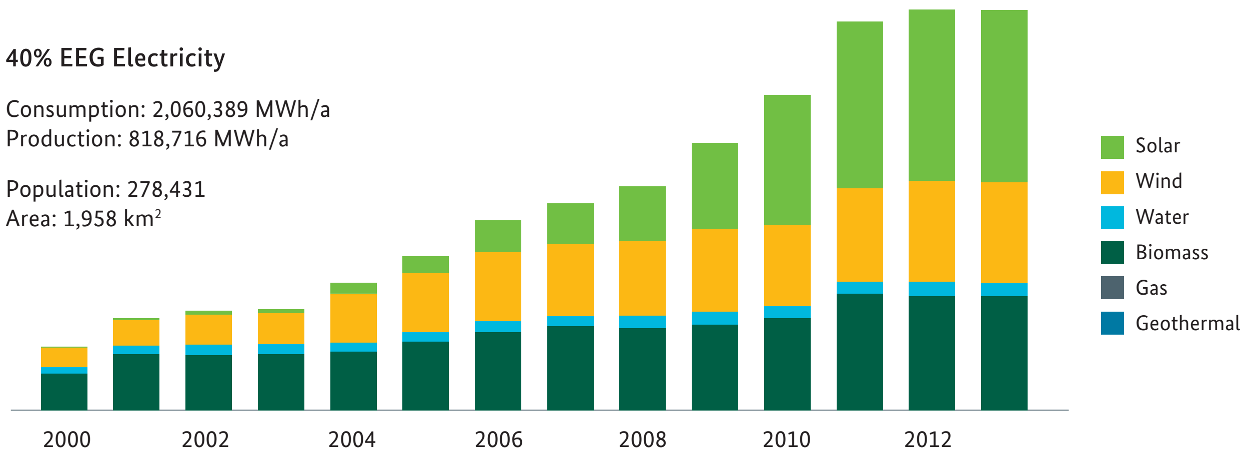
Problems related to food production (as demonstrated by Ebbinghof)

In this overwhelmingly positive and most convincing scenario, a few critical questions may be in order nonetheless. If, along with farm slurry, manure and grass-cuttings – all of which represent agricultural wastes and residues which would have been produced at any rate – maize silage is used in Ebbinghof’s biogas plant, shouldn’t one ask what was cultivated on the land required for maize production prior to now? And what could be cultivated there instead? If biomass production and intensive livestock rearing take off as a result of inexpensive and abundant bioenergy, shouldn’t more grassland be taken under the plough to grow energy and feed crops? Grassland is very important for carbon sequestration in the soil, and, more generally, as refuge for biodiversity in agricultural landscapes. Grass cuttings from landscape management may be used as silage too, but so far haven’t been fed into fermenters as extensively as energy crops (4,000 t/a in Ebbingshof as opposed to 10,000 t of maize). All of this begs another fundamental question, and a very decisive one, one with regard also to development cooperation: Would ‘bioenergy villages’ like Ebbinghof exist at all if it wasn’t for the German Renewable Energy Act and its financing mechanisms? – No, they certainly would not! At least not to the same extent.

Insights from LEADER region Sauerland at the intersection of sustainable energy and food

If anything, this abrupt and very definite retort goes to show that political incentive systems are most crucial to increasing the share of renewables in a given energy mix and economic scenario; this not so much in the sense of generating a favourable political climate and public opinion congenial to an overall sustainability transition, as much as establishing the framework conditions under which renewable energies might become commercially viable in the first place. Experience from regional man-

Renewable Energy in the Hochsauerlandkreis



Proportional growth of types of energy

agement for LEADER in the Sauerland shows that most decisions to install renewables are based on business considerations, pure and simple. What regional management can do is encourage projects in the planning phase to pay closer attention to added value and local ownership, and to boost rural development overall by supporting grass-roots initiatives, such as farm shops and regional brands, which will serve to give renewables a strong community foothold in the long run. In this sense, renewable energy projects in Germany very much resemble those in developing countries, which also have at their heart an overriding concern for using resources locally and creating value right where these resources are produced, processed and consumed – at their doorstep. By contrast, direct links and overlaps with the food industry, are much looser and rarer in Germany. Here, commercial use of renewable energies, for example in local distributed heating systems such as the one in Ebbinghof, plays a much greater role than any possible effects of renewables on food production and food security. Even maize, the much maligned energy crop of the day, is in most places still cultivated as a feed crop, and powers biogas plants only incidentally.

Discussion: Brief Reflection on Morning Events by the Organisers

***Christel Weller-Molongua**, Director of Division 'Rural Development and Agriculture', Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*

***Dr Tilman Altenburg**, Head of Department 'Sustainable Economic and Social Development', German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE)*

A solid foundation: Technical solutions and a new paradigm

Going through the six presentations that marked the morning sessions of the symposium – from the German 'ONE WORLD – No Hunger' initiative with its focus on food security, to the hands-on experience with renewable energy systems provided in the last two presentations – for Cape Verde by Prof. Dr Heck and for the LEADER region of Sauerland by Mr Pletziger – one is reassured to see that a wealth of technical solutions already exist at the intersection of sustainable energy and food. The nexus is by no means uncharted territory, but has been amply explored at all levels pertaining to development cooperation; from political target-setting in government offices and at the tables of international conferences to the daily round of a regional manager in the German countryside. The provenance of all six speakers in fact testifies to the very advantageous position that Germany holds with regard to the challenges for sustainable energy use in the agriculture and food industries, and which make it a suitable candidate for the advancement of new solutions in the world arena. Germany possesses a rich and diverse academic landscape, with institutions such as Mr Uwe Fritsche's International

Christel Weller-Molongua (left) and Dr Tilman Altenburg (right) during the panel discussion with moderator Monika Hoegen

Institute for Sustainability Analysis and Development, and Prof. Dr Heck's Institute for Applied Material Flow Management, both working at the very forefront of research. Yet Germany is also the stage for a most critical, most vibrant public discourse about sustainability; from which, ultimately, a new paradigm may spring to accompany technical solutions exported into the developing world.

Problems in implementation: Stakeholders and impact on broader scales

Engineering know-how and economic prowess, unfortunately, do not guarantee successful implementation under all circumstances. Food production in Africa has been stagnating for the past 40 years and the absolute number of those with no access to modern energy services on that continent is actually higher today than it was only a few decades ago. Clearly, there is room for much improvement when it comes to implementation. Development cooperation must look in two opposed directions if it wishes to improve on its performance and to make its remarkable local successes last. On the one hand, applications must always be site-specific and adapted on a continual basis to changing local conditions. The resources and capitals available at a given site may vary from context to context, and so may the level of compliance and acceptance of proposed measures within a given populace. Culture-sensitive, anticipatory stakeholder-management remains a central issue for development cooperation. For pilot projects to take off, confidence-building is almost as important as capacity-building. On the other hand, successful projects remain largely fruitless if they are not scaled up and applied on a broader basis. Mainstreaming, for good reasons, is one of the buzzwords of modern development cooperation. It is the responsibility of international donors to negotiate with local governments and decision-makers to ensure a broad-based roll-out of technologies, and to firmly anchor sustainability on both their local and international agendas. Sustainable Development Goals should never be a dead letter at the negotiating table.

A systematic approach: About the complementary aspects of development cooperation

Development cooperation needs to navigate between these two, always interrelated spheres – that is, between the local and the global. Its approach has to be entirely systematic. Where do conditions in a certain region depart from a generally favourable overall framework, and thus hinder its implementation? Where are local initiatives – be they political or commercial – thwarted by forces beyond their present control? Financing is a telltale example in this respect, as it bridges both spheres: speakers at the conference were in fact unanimous in demanding that renewable energy projects be financed locally in order to create added incentive and employment. However, where the initial expenditure required for modern technological applications is too high to be financed by such micro-economic means alone, the need for international credit and/or investment is often inevitable. This, in turn, invariably raises new questions for the overarching energy-sector design, and indeed, for the climate of global investment in general. It should be obvious at this point that a thoroughgoing context analysis, always taking into account the various and complementary aspects of development cooperation, is indispensable to the planning phase of any project. Aside from this, GIZ's now established three-level approach remains as effective as ever: to further develop cooperation, one must both clearly address and reach out to the target group, and never fail to keep in mind what technical level of competence is required for a project – linking up, wherever possible, with the relevant government agencies and departments that may help one implement one's designs.

Powering Agriculture: An Energy Grand Challenge

***Jeremy Foster**, Programme Analyst Energy & Environmental Policy, United States Agency for International Development (USAID)*

‘Powering Agriculture: An Energy Grand Challenge for Development’ (PAEGC) is an initiative designed to facilitate a broad and multifaceted task: to further integrate clean energy solutions into developing countries’ agriculture sectors as a means of increasing agricultural productivity and value. Powering Agriculture is co-financed by a diverse, international cadre of public- and private-sector partners: the United States Agency for International Development (USAID), the Government of Sweden, the German Federal Ministry for Economic Cooperation and Development (BMZ), the US-based energy utility Duke Energy Corporation, as well as the Overseas Private Investment Corporation (OPIC) – the U.S. Government’s development finance institution. Recognizing that the assimilation of innovative technologies and practices in the clean energy and agriculture nexus is key to the programme’s success, Powering Agriculture is also working with GIZ to develop a ‘wiki’ knowledge-sharing platform. This information hub – along with links to a wealth of other resources relating to the programme, its partners, and projects – can be accessed through the initiative’s primary website, www.PoweringAg.org. On this site, potential applicants for Powering Agriculture funding can also learn about upcoming solicitations and calls for proposals.

PAECG Partners

Energy in the Agricultural Value Chain

Inputs	Production	Local Transport/ Collection	Storage & Handling	Processing
→ Seed → Water → Labour → Fodder → Fertiliser → Equipment	→ Growers or Cooperatives → Horticulture → Livestock → Aquaculture → Dairy/Meat	→ Truck → Bicycle → Train → Boat → Animal → On Foot	→ Pre- or Post-Processing → Storage → Silos → Cooling → Brokers & Traders	→ Drying, Grinding, Milling, etc. → Food & Feed → Ingredients

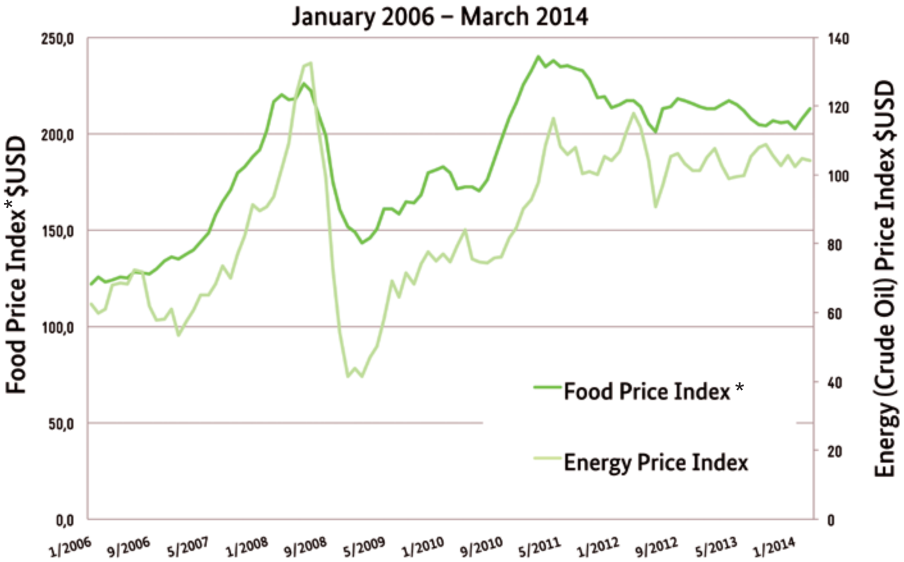
BEYOND POWERING AG

Transport & Logistics

Marketing & Distribution

End User

Food Prices as Opposed to Crude Oil Prices, 2006–2014



* The FAO Food Price Index is a measure of the monthly change in international prices of a basket of food commodities. It consists of the average of five commodity group price indices – cereal, vegetable, dairy, meat and sugar – weighted with the average export shares of each of the groups for 2002-2004.

Energy in the agricultural value chain

Within the various stages of agricultural value chains, there are multiple opportunities for increased use of clean energy. In the sector at large, the steps involved in getting agriculture products from the farm to the table can be highly energy-intensive. This holds for the production of agricultural inputs such as fertilisers and animal feed, for pumping and irrigation, on-farm mechanization, livestock rearing, refrigerated storage and cold-chain facilities, as well as for a range of sorting, processing and packaging activities that add value to agricultural commodities. Though beyond the scope of Powering Agriculture itself, significant energy inputs are also needed in the transportation and logistics management of agricultural products, wholesale/retail marketing and sales, and in consumer food-preparation at home. The United Nations Food and Agriculture Organization (FAO) estimates that the food sector currently accounts for approximately 30% of the world's total energy consumption, and contributes to over 20% of global greenhouse gas (GHG) emissions.

The price of food is tied to energy

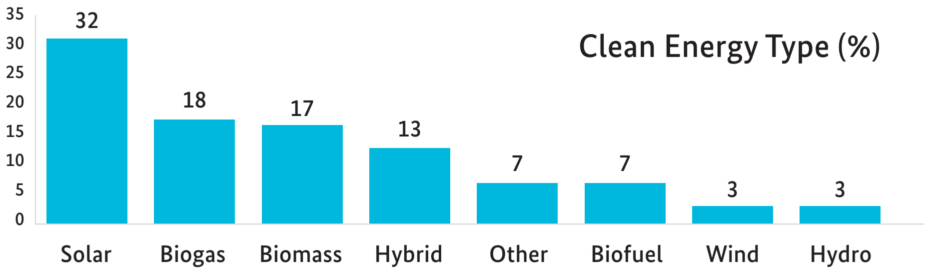
Globally and historically, the agriculture sector has been primarily driven by fossil-fuel inputs. Breaking away from this dependency is not only an environmental imperative, but also makes economic sense. Although there is no direct parity, a strong co-movement can be observed between food and energy prices, as evidenced in the changes of stock-market price indices for food and crude oil over the last decade.

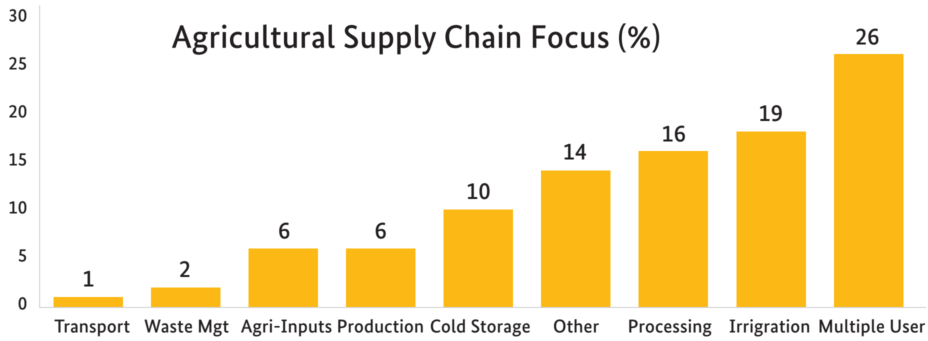
Any effort to increase the development and deployment of renewable energy technologies in this context will help decouple the prices of fuel and food. This can have a positive effect on food security worldwide, and will be increasingly important as the global population continues to rise. FAO estimates that by 2050, current agricultural production must increase by 70% in order to ensure there is enough food for our growing population. Accordingly, it is essential that land under agricultural cultivation be managed more efficiently in the future – both with regards to improved agricultural practices and to reduced energy consumption. On a global scale, FAO estimates that nearly a third of edible agricultural products grown is wasted, rather than consumed. In India, about 18% of fruits and vegetables – valued at more than $2 billion (USD) annually – goes to waste due to insufficient access to cold storage facilities. Only 6% of Africa's cropland is currently irrigated in a systematic manner, which limits production capacity. Clearly, there are opportunities to increase efficiencies throughout the agriculture sector, to ensure more food is produced and a greater amount of quality goods reaches end-consumers.

The challenge: Powering Agriculture helps overcome market barriers

What appears to be a 'grand challenge' within the agriculture sector is also an immense market opportunity. The provision of reliable clean energy services to areas in need represents a potential $700 billion market, in which the private sector – supported by public-sector government entities – can be actively engaged. Powering Agriculture is built around the premise that by increasing access to

PAEGC Global Innovation Call 2013



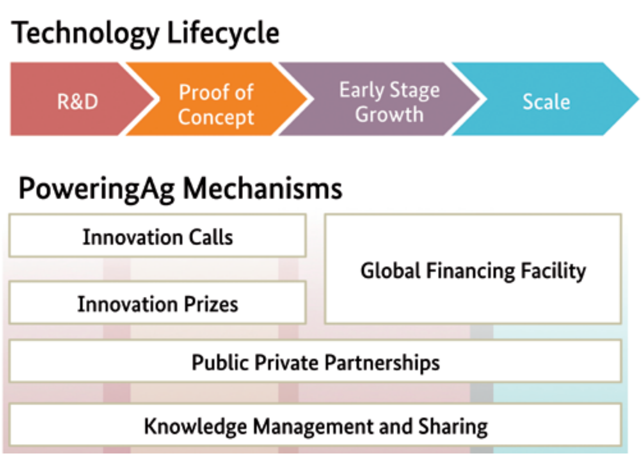


clean energy services, farmers and agribusinesses in the developing world can improve their output and the market value of the goods they produce. Catalysing resources from partners and innovators around the world, the initiative is working to identify ways in which these services can be adopted within agricultural value chains to reduce energy costs and promote environmentally-sound economic growth. However, significant market barriers remain which must be overcome. One such barrier is limited demand: farmers are often not aware of new technologies that could help them improve operational efficiencies. Moreover, much of the on-farm mechanization that works in developed countries may not be technologically feasible in the developing world, or simply be too costly. Limited access to financing is another hurdle. While operational costs for renewable energy technologies are generally low, there is often high initial investment. Both the agricultural sector in developing countries and the clean energy sub-sector are inherently risky areas. As a result, there are very few replicable business models in this space that could readily attract commercial financing.

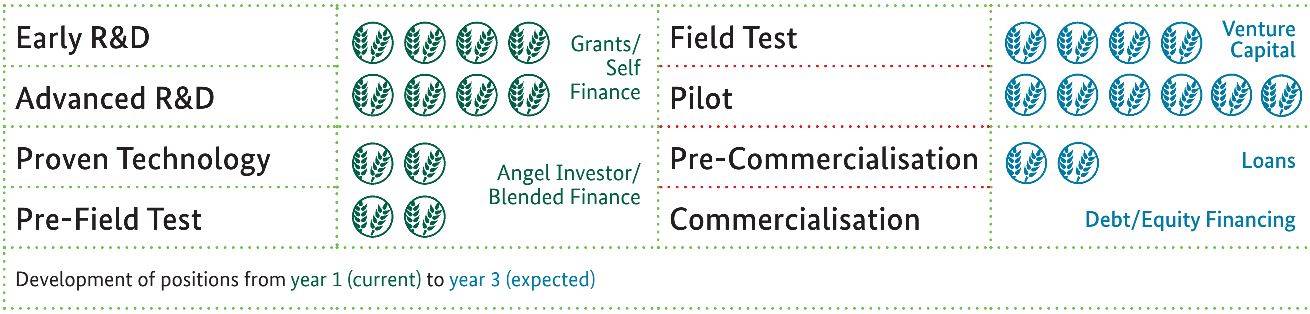
Providing support for the entire development of an enterprise

At this stage of implementation, much of Powering Agriculture's work focuses on early-stage technological development, providing grant funding to innovators to progress from basic research and development to designing prototypes that can be deployed in emerging markets. The ultimate goal is to assist these innovators in developing sustainable business models so they can propel their clean energy solutions to commercial scale. Powering Agriculture employs a number of different mechanisms to provide this support. The most prominent mechanism is Global Innovation Calls, through which for-profit and non-profit firms and organisations can submit proposals for funding. Powering Agriculture also reaches out to private sector entities, with the aim of establishing partnerships and technology transfer arrangements to support growth within the clean energy and agriculture nexus. Further, the programme is developing a Global Financing Facility which will assist clean energy enterprises and

PAEGC Focus and Support Instruments



PAEGC Portfolio



agribusinesses with an interest in adopting clean energy technologies in securing debt and equity investments. All piloted interventions are documented and lessons learned are widely disseminated so that successes can be shared with and built upon by other actors engaged in this space. It is envisioned that support for new innovations in clean technology – whicht is specifically designed for agrarian markets in developing countries – will contribute to measurable results in terms of reduced GHG emissions and in increasing agricultural production and value.

Funding through Powering Agriculture: Global Innovation Call 2013 and results

In 2012, Powering Agriculture released its first Global Innovation Call for proposals; a second call will be released in autumn 2014. For the first call, 475 proposals were received from applicants hailing from nearly 80 different countries. Approximately, 40% of the proposals submitted were from developing countries. The proposals came from a wide range of applicants, including for-profit companies, non-profit organisations, academic institutions and foundations. The proposals spanned the entire range of renewable energy options, from solar, biogas and biomass – the three most prevalent technologies – to biofuel, wind, hydro, and hybrid generation. The agricultural foci of the individual proposals were likewise quite diverse, involving multiple stages of agricultural value chains – including agri-input production, irrigation, value-added processing, local transport and cold storage.

After careful evaluation, Powering Agriculture awarded a total of $12 million to fund 11 projects through its first Global Innovation Call. Among the awardees is iDE (www.ideorg.org), which is working in Honduras, Zambia and Nepal to develop and market a hybrid solar photovoltaic- and solar steam-powered piston pump for drip irrigation systems, which is cost-competitive with diesel-based systems. Another awardee, EarthSpark International (www.earthsparkinternational.org), is developing a solar-powered micro-grid system in Haiti that will provide electricity to agriculture processing facilities and surrounding households through a prepaid smart metering system. SunDazer (www.sundanzer.com) is a private-sector awardee that is developing a solar-powered refrigeration system for the Kenyan dairy industry. CAMCO Clean Energy (www.camcocleanenergy.com) has developed a small-scale village-level biomass power plant in Tanzania. The plant runs on agricultural waste and provides electricity as well as thermal and mechanical energy to the local community for value-added processing and social services, such as schools and health clinics.

Current portfolio position and future development of financing

For its first cohort of awardees, Powering Agriculture is primarily funding projects in the early research and development stage. Over the long run, however, the initiative aims to provide support to innovators who have the potential to bring their solutions to commercial scale. In the first year of implementation, it is expected that most projects in the portfolio will focus their resources on developing proofs of concept and/or field-testing their technologies. By the end of the third year, it is envisioned that many of the innovators will have established pilots and be able to demonstrate their potential for commercial viability. Powering Agriculture would like to see the innovators it supports strengthen their businesses so they become eligible for a wider range of financial services – from venture capital investments to commercial debt and equity financing. Powering Agriculture's long-term objective for all projects is to promote commercially viable businesses active in the clean energy and agriculture nexus that are able to further expand operations without international donor assistance.

Powering Agriculture: Network and Wiki Portal

***Maria Weitz**, Senior Project Manager 'Powering Agriculture – Sustainable Energy for Food', Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*

Teaming up with the United States Agency for International Development (USAID) and its numerous partners to form the global initiative 'Powering Agriculture: An Challenge for Development' (PAEGC) was a strategic decision on the part of the German Federal Ministry for Economic Cooperation and Development (BMZ). Not only because the ministry readily subscribed to the initiative's overall agenda – the integration of clean energy solutions into developing countries' agriculture sectors as a means of increasing agricultural productivity and value – but also because BMZ and GIZ saw an eminent need for closer cooperation and information exchange between science, development cooperation and the private sector if the programme were to be successful. Producing more food with less energy, in an agriculture sector that should be powered to a much greater extent than it is today by renewables, is indeed a grand challenge; it can only be mastered in a systematic cooperative effort that crosses institutional and disciplinary boundaries. This is precisely where the GIZ project comes in – and what gave the symposium its purpose: a kick-off meeting for a network of experts and stakeholders to support personal contact and exchange.

Tasks Within German PAEGC Contribution

The German contribution to 'Powering Agriculture: An Energy Grand Challenge for Development'

Giving Powering Agriculture its very own spin, 'Sustainable Energy for Food' complements the flagship initiative not only in title, but in three meaningful ways: as mentioned before its main purpose is to foster an expert network in the field. Additionally, the project offers applied practical training on questions pertaining to the energy and food nexus. For this, it cooperates closely with educational institutions in developing countries and emerging markets, devising locally adapted courses and seminars, and seeing to their ultimate inclusion on the curriculum. The third area of project activity addresses the commercial side of the issue. In cooperating with local partners from the private sector and other development programmes with a focus on agriculture and energy, GIZ intends to set up model projects that offer viable technological (and commercial) solutions that may also be replicated in other contexts and on broader scales. The expert network can serve as an efficient vehicle for knowledge sharing and transfer in this respect.

Be part of the solution!

Contribute to the global knowledge network for energy and food. Subscribe to the PoweringAg Newsletter at

→ www.PoweringAg.org

or register at

→ https://energypedia.info/wiki/Portal:Powering_Agriculture

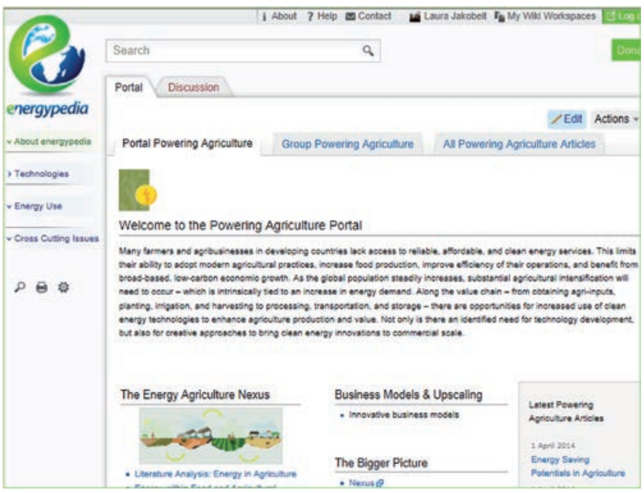
More than 4,000 users have already signed up!

A network for Powering Agriculture

The idea for a network of people with a stake in the energy and food sectors – from scientists and researchers, to politicians, entrepreneurs and investors, to representatives of civil society – was sparked by a somewhat disappointing literature review: in skimming through the relevant publications to date, it became clear that scientifically valid analyses within the nexus were sparse, that great gaps still existed in terms of thematic coverage, and that best-practice examples and experience reports were generally in short supply. To remedy this general lack of evidence, GIZ is working to bring together all stakeholders via its network and thereby to tackle the most urgent questions in a joint national and international fashion: What needs to be done next? What are pertinent areas of research in the context of sustainable energy and food? Where do successful models exist? What can be learned from them? Powering Agriculture's focus is clearly one of knowledge management and dissemination – sharing here serves synergies.

Wiki portal 'Powering Agriculture'

While the symposium marked the official launch of the network, and was intended in part to help forge the first personal links among community members, the bulk of communication and exchange will take place via a wiki portal on Energypedia – the backbone of what actually is a virtual Powering Agriculture network. Registered users of the platform have access to materials from fellow professionals, scientists and opinion leaders in energy and agriculture, or may decide themselves to contribute, in the form of articles, comments on existing content, or new discussion threads for others to respond to. They can use the portal to flag up their own events or publications, and in doing so will reach experienced experts around the globe. The wiki portal is designed as a virtual meeting point and information hub for stakeholders, and since its inception in May 2014 it has been growing continuously. One substantial contribution to the site in the meantime has been the addition of a comprehensive database on clean energy technologies in the food industry. It provides individual details for 60 technologies in total, including how and where in a given agricultural value chain a technology can be used, from whom it can be obtained (manufacturers), what is required for maintenance (technology and infrastructure), and so on.



https://energypedia.info/wiki/Portal:Powering_Agriculture

GIZ's role as facilitator of dialogue and exchange

Though the technology database and other initial inputs were orchestrated by GIZ, the portal depends on contributions from its users in order to grow into a lively point of exchange; GIZ only provides the framework for this dialogue. Rather than consisting of ready-made concepts and pre-formatted content, Powering Agriculture is meant to be a creature of its own making – by stakeholders for stakeholders. In this sense, the symposium represented an important step in bringing the platform to life, even beyond its first and foremost function of enabling personal networking. It also helped the project management gauge the interests and needs of its target audience. The working group sessions in the afternoon, for example, were specifically designed for this purpose. Their output, as well as this conference documentation, are valuable resources in making Powering Agriculture an effective and vibrant network, whose voice will reverberate throughout the sector.

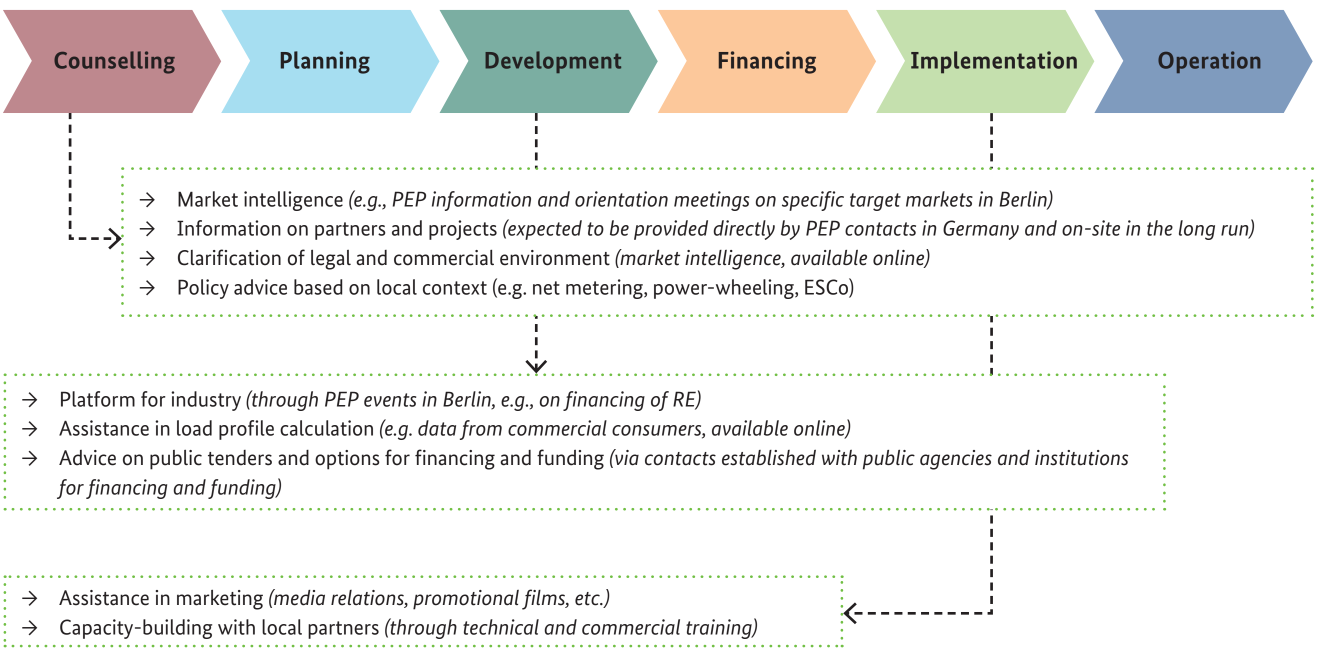
Working Group I. Cooperation with the Private Sector

The Project Development Programme Within the Renewable Energies Export Initiative

***Tobias Cossen**, Advisor Project Development Programme, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*

The Project Development Programme (abbreviated as 'PEP' based on the programme's German designation) is an extension of the Renewable Energies Export Initiative (EEE) that was launched in 2003 by the German Federal Ministry for Economic Affairs and Energy (BMWi) to foster foreign trade of German companies in the renewables sector. PEP itself was initiated in 2007, with the specific purpose of catering to developing countries and emerging economies as target markets for German renewables technologies and services. GIZ is the implementing agency on behalf of BMWi; its main clients are German small- and medium-sized businesses that wish to enter these markets. GIZ offers support for market entry and project implementation, but also works to develop a generally favourable and sustainable framework for business transactions between suppliers and buyers. Its main target regions are sub-Saharan Africa, including Kenya, Tanzania, Ghana and Mozambique, as well as Southeast Asia, with primarily Thailand, Philippines, Indonesia and Vietnam as bases of operations. Particular competence and know-how in terms of technology exist for PV and Diesel installations, as well as mini-grids and energy storage. Questions of financing also fall within PEP's area of expertise; as do on-site consumption, direct marketing and energy servicing companies (ESCo).

Support Provided by the Project Development Programme (Examples)



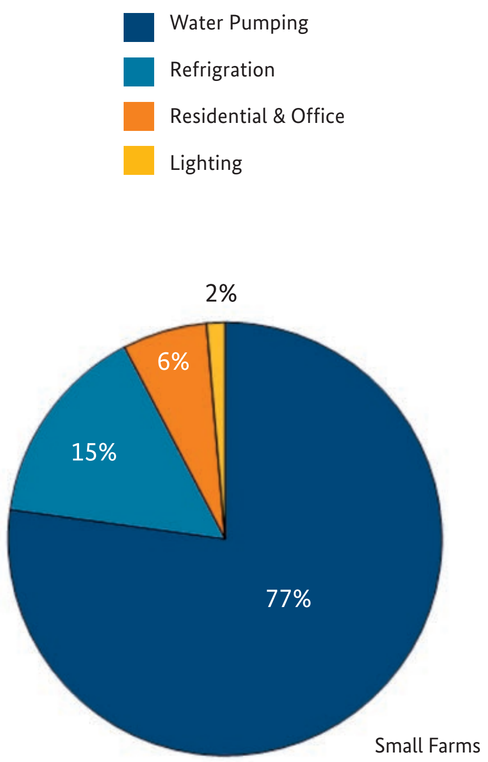
Heading for new shores: Experience in cooperation

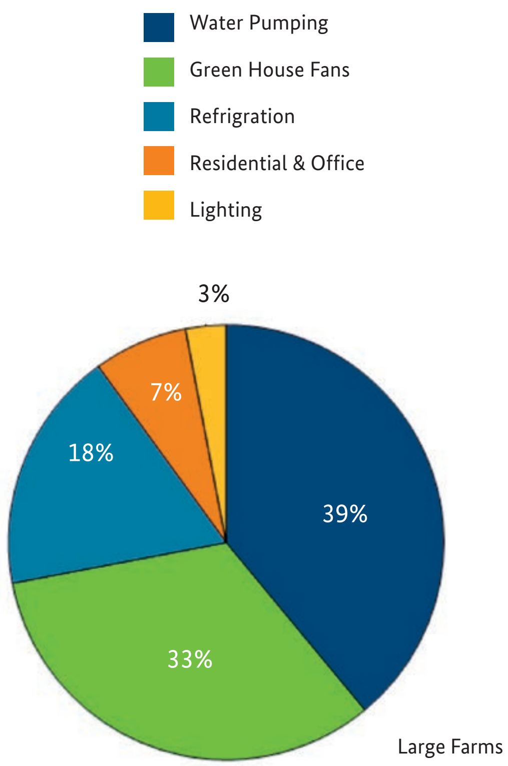
The renewables market in Germany is well on the way to reaching its saturation point. Growth in the bio-gas segment has almost ceased. The same is true for photovoltaics (PV) in open spaces (free-field PV), and to a lesser extent for PV arrays mounted on residential buildings, which are still slightly increasing in numbers. Wind is the only technology to date displaying solid growth, though only after a serious blow dealt by the 2012 amendment of the German Renewables Act (EEG), which significantly cut feed-in tariffs for wind-energy. It is absolutely unclear how this market will develop in the future. After years of easy money and relative prosperity, German enterprises in the renewables sector must look elsewhere for their business. The comfort of the past, however, as well as the constraints of the present, with its inevitable market shakeout and considerable financial strain, do not make it easier to meet the challenges of the new. Particularly, in the case of developing countries, which would require innovative products and business models designed for slow but steady returns. Instead, the advances and financing necessary for project development are increasingly cut from budgets to minimise risk, and so the economic focus shifts towards the beginning of the value chain, favouring short-term gain over strategic long-term orientation. This is all the more lamentable as legislators in the developing world, after what might be called a long, shaky phase of trial-and-error, are now beginning to stabilise the framework for market entry and participation in their countries. Public tenders for power purchasing agreements and off-grid installations, hitherto annexed with stringent regulations for foreign participation, are giving way to regulated procedures of government intervention. Feed-in tariffs and net-metering are now being introduced. This will render market research much easier, and market development much more predictable.

Flower farms in Kenya as an example for a potential market segment

More than 100 flower farms currently operate in Kenya, 68 of which are members of the Kenyan Flower Council (KFC). Three farms have already invested in PV installations, with a nominal power of 60 to 100 kWp each. Solar energy holds great promise in this segment as most of the electricity consumed by flower farms is used during the day – for irrigation (water pumping) and for cold storage

Typical Power Consumption of Flower Farms in Kenya





of cut flowers (refrigeration, particularly on larger farms). One typical example of such a farm is Masai Flowers Ltd. of the fairtrade-certified Sian Roses Group. At a size of 20 ha, and over 365 days of operations, the farm consumes about 895,315 kWh in electricity (2012), taken either from the grid, at a rising Ksh19.40 per kWh (roughly €0.16), or produced on-site via a back-up Diesel generator. There is enough stable roof-top space to mount a PV array with capacity sufficient to meet daily consumption. Yet, Masai Flowers Ltd. is unfortunately also typical of Kenyan flower farms in that it does not possess enough funds to act as an independent buyer of PV, or rather, in that it prefers to allocate its capitals differently: for the expansion of farm grounds and the construction of more greenhouses. These latter can be amortised within approximately two years, whereas a PV installation would need about 6.5 years for recovering all upfront cost. Another damper for potential PV suppliers from Germany: Kenya already has a well established PV 'scene', with producers and project developers contacting industry clients, including flower farms, via cold calls. In order to be successful in this business, direct contact with the customer is indispensable, and it should ideally be accompanied by holistic, innovative financing concepts, which make up for the drawbacks of PV in such a setting. The problem, however, is not endemic to Kenya. Credit of the size required for renewables projects is often not readily available in developing countries, so pioneers among end-customers need to pay in equity – unless, that is, the supplier can offer an attractive financing scheme.

Cooperation with the Private Sector

Objectives

- → Establish GIZ/PEP as liaison / (innovation) platform for B2B and B2C contacts
- → Achieve transferability and scalability through support and assistance
- → Develop reference projects: 'seeing is believing'
- → Create sustainable framework through policy advice tailored to industry needs

Lessons learned

- → Cooperation with the private sector only in cases where it can add concrete value.
- → Continuous close contact with companies and markets is essential, also (and especially!) in building one's own expertise and competence.
- → You cannot force reference projects! They must be initiated, and owned, by the companies involved.

Sustainable Energy for Food: What can KfW do?

***Klaus Gihr**, Head of Division 'Sector Policy', Competence Centre 'Energy, Water and Agriculture', Kreditanstalt für Wiederaufbau (KfW)*

Financial development cooperation works primarily with public sector entities, so its general work focus is on framework conditions and on providing the appropriate infrastructure for businesses and projects to succeed. For reasons of neutrality in competition, but also for transaction costs, which are particularly high for small projects, only those endeavours in excess of €5 million (EUR) tend to receive direct credit from KfW. Private enterprises of small and medium size seeking financial support are normally referred to the finance sector at large. In Germany, these companies may approach the Deutsche Investitions- und Entwicklungsgesellschaft (DEG, 'German Investment and Development Society'), a subsidiary of KfW, or apply to be funded by develoPPP.de, a programme launched by the German Federal Ministry for Economic Cooperation and Development (BMZ) to foster cooperation between the private sector and development policy. This programme provides companies investing in developing countries and emerging markets with financial and, if required, professional support as well. The companies are responsible for covering at least half of the overall costs; BMZ contributes up to a maximum of €200,000. These development partnerships with the private sector may last up to a maximum of three years and cover a wide variety of areas and topics – from eco-certification in Serbia to vocational training in India. BMZ has appointed three public partners to implement the programme on its behalf: DEG, GIZ and sequa gGmbH. Companies taking part in develoPPP.de always cooperate with one of these public partners. Since the launch of the programme in 1999, DEG, GIZ and sequa have realised over 1,500 development partnerships with German and European companies.

Examples of financial development cooperation with direct involvement of KfW

KfW is active in a multitude of areas pertaining to sustainable energy and food. For one, it has established, or holds substantial shares in, several funds that support agricultural production, particularly with regard to processing, innovation, and energy efficiency therein. Together with the European Investment Bank, for instance, KfW initiated the Green for Growth Fund (GGF), the first specialised fund to advance energy efficiency (EE) and renewable energy (RE) in Southeast Europe, including Turkey, and the nearby European Eastern Neighbourhood (www.ggf.lu). GGF provides refinancing to financial institutions so that they can enhance their participation in the EE and RE sectors, but also makes direct investments in non-financial institutions with projects in these areas. Another example is EFSE, the European Fund for Southeast Europe, which offers sustainable funding to micro and small enterprises, as well as to low-income families assisting them in the improvement of their housing conditions (www.efse.lu).

KfW is of course also involved in financial development work beyond the borders of Europe. In Madagascar and the Democratic Republic of Congo, it is currently financing projects that promote so-called energy forests, that is, agroforestry systems based on short-rotational wood. Rural energy programmes under its funding are being implemented in West-Nile Uganda (with a focus on thermal power stations, T lines, and rural access to energy and counselling), in Mali (PV hybrid mini-grids), as well as Nepal and Bangladesh (biomass for clean and sustainable cooking energy). In South Africa, KfW supports the national off-grid Solar Home System (SHS) programme.

Public-Private Partnerships (PPPs): 'Energy Efficiency in the Tea Value Chain' as a Case Study

***Charlie Moosmann**, Advisor 'Powering Agriculture – Sustainable Energy for Food', Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*

'Energy Efficiency in the Tea Value Chain' as a partnership between public and private entities in Kenya, is the result of a somewhat natural process of business development on the part of all three parties involved: GIZ, Betty & Taylors of Harrogate (ToH) and Kenya Tea Development Agency Ltd. (KTDA). For GIZ, it was but a logical step to advance along the value chain from its previous cooperation with the Ethical Tea Partnership (ETP). Having focused on energy supply for cooking and climate adaptation in small-scale tea cultivations during this first cooperative effort, it seemed natural for GIZ to move on to efficient energy use in tea leaf processing, i.e., in withering, crushing, tearing, rolling and drying. Optimised energy flows here would directly benefit smallholders and heighten their competitiveness. ToH, by contrast, is an expanding British tea company that intends to cut by half the CO_2 emissions along its supply chains as part of a strict and committed strategy of sustainability. Being a founder member of ETP, they were quick to link up with GIZ on a shared energy-efficiency focus. Finally, the KTDA, representing as it does a total of 63 tea processing facilities held in partial ownership by about 565,000 Kenyan smallholders, has a vital interest in acquiring data for improving investment decisions. KTDA also has an interest in developing and testing methods of tea processing that are quick and easy to apply to other production sites under their management.

From planning to implementation

Once the idea of a Integrated Development Partnership (see table) had taken form in consultations between GIZ and ETP, a busy seven-month phase of planning ensued. During this phase, ETP and GIZ, the latter represented by Powering Agriculture, developed a proper project design for improving energy efficiency in the tea processing industry. This in turn convinced ToH to contribute financially to the project. As the terms of reference were being prepared, KTDA joined as a third partner. The agency agreed to collect energy data centrally at its headquarters in Nairobi, as well as in four processing facilities throughout the country over the duration of the project; it will however also watch over tea quality standards with the drafting of recommendations. Training and recommendations for management decisions fall within its mandate, too. ToH, through ETP, will support submissions to KTDA management. They will help in developing materials for training and public relations; including videos, good-practice guidelines and case studies. Technical and methodical supervision in this scenario lies with GIZ. They will conduct the necessary energy audits and cost-benefit calculations. Training content and quality is also a focus on their agenda.

Expected results

If all project parties deliver on their obligations under this partnership, the project's management team, consisting of staff from ETP, KTDA and GIZ, expects to have at their disposal towards the end of the first project phase a set of technology and profitability assessments for all measures recommended as raising energy efficiency in the tea processing value chain. After the project, KTDA should be able to offer energy audits and profitability analyses themselves, while their investment decisions, now informed by those assessment results, should bring about considerable improvements in terms of energy efficiency and CO_2 emission reductions. These latter should be measurable in ToH's supply chains, as well, and give credit to their own sustainability strategy. All this can raise the value of shares in the whole enterprise, and thereby contribute to solidifying the market position of tea producers represented by KTDA. However, as of now, in the full process of project implementation, a word of caution may nonetheless be in order.

Over the first few months of negotiating the project, it has become clear to all involved that perspectives differ significantly according to where a partner sees itself – in business or in development cooperation. This is hardly surprising in itself, but should serve as a reminder to all those seeking to establish PPPs that it is always important to set aside a certain time at the beginning of a project for harmonising differing concepts and views.

Cooperation with the Private Sector at GIZ

	Integrated Development Partnerships	**Employment for Sustainable Development in Africa (E4D)**	**PPP Fund for Cooperation with Companies in Mano River Union Countries**	**Ideas Competitions**	**Strategic Alliances**
Private Partners	All companies (local, regional and international)	Companies based in Africa, international companies with branch offices in African countries	Companies based in West Africa	German and European Companies	German and European Companies
Sectors	Contributes directly to achieving targets of technical cooperation project	E4D target countries: Cameroon, Ghana, Kenya, Mozambique, Zambia, South Africa, Tanzania, Tunisia, Uganda; projects aim to achieve impact on employment, income and working conditions in focus sectors of German development cooperation	West Africa (Guinea, Ivory Coast, Liberia, Sierra Leone); projects related to focus sectors of German development cooperation	Projects in diverse sectors	Supra-regional, often entire sectors; various stakeholders
Duration	Within project duration	Up to 3 years	Up to 3 years	Up to 3 years	Up to 3 years
Amounts Covered	Public contribution subject to (i) local terms and conditions of call and (ii) value of call according to offer (maximum of €207,000)	Up to €200,000 in public contribution GIZ ≤ 50%	Up to €200,000 in public contribution GIZ ≤ 50%	Up to €200,000 in public contribution GIZ ≤ 50%	Not below €750,000 in total GIZ ≤ 50%
Partner Acquisition	Active acquisition	Active acquisition	Active acquisition	Through competitions, counselling by GIZ	Active acquisition
Public Funding via	technical cooperation project	E4D	PPP Fund for cooperation with companies in Mano River Union countries	develoPPP.de (see page 43)	

Overview of all possible modes of cooperation with the private sector at GIZ

Criteria for Participation in develoPPP.de

→ **Compatibility:** All projects must demonstrate clear relevance to development concerns and be environmentally and socially sustainable. Projects that conflict with the development-policy objectives of BMZ will not be funded.

→ **Complementarity:** Public and private contributions should complement each other in such a way that cooperation enables both partners to achieve their respective objectives more quickly, more efficiently and more cost-effectively.

→ **Subsidiarity:** A public contribution will only be made in situations where the private partner would not otherwise implement the project without the public partner, where the project is not required by law, and where it gives rise to appropriate economic and development benefits for the developing country.

→ **Competition neutrality:** Competition must not be comprised by the project.

→ **Contribution of the private sector:** The company must make a substantial financial contribution representing at least 50% of the project's total costs.

→ **Commercial interest:** The company must demonstrate a clear commercial interest in the project. Non-profit projects cannot be funded within the scope of the develoPPP.de programme.

→ **Sustainability:** A develoPPP.de project must be tied to the long-term involvement of the company in the developing or emerging country. Special emphasis is placed on sustainability beyond the term of the project.

Presentation of Results: Cooperation with the Private Sector (Working Group I)

***Moderator: Judith Helfmann-Hundack**, Development Cooperation Scout, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*

Challenges...

→ In cooperation with the private sector, more attention needs to be paid to local farmers and, most generally, to the requirements of agriculture. However, there remain considerable knowledge gaps on the part of those that development cooperation wishes to reach. Market intelligence-systems are often inadequate, and awareness of existing technical solutions is lacking, particularly in remote, rural areas. Calling for the stronger involvement of smallholders in cooperation thus requires a greater degree of maturity and/or knowledge on *their* part as well.

→ In project implementation, collaboration amongst partners should be improved, and respective forces combined, in a more target-oriented manner for efficient and timely execution.

→ It is essential to understand the needs of local industry. Why is a partner country interested in a particular project? What particular benefits does its industry derive from a partnership? Certification of tea production in Kenya, for instance, is not only driven by environmental commitment, or purely ethical concerns; it is also a direct response to a very tangible economic problem: the continuing decline in that country of timber stocks needed for tea processing.

→ Partners in public-private partnerships (PPPs) generally need to know more about each other than they presently do.

→ Development banks such as KfW are asked to rethink their priorities. Currently, they are mostly financing 'mainstream' technologies, that is, mature technologies that have proven their worth in a number of applications. But what does 'mature' and 'test-proven' in this context actually mean? And are these really what is needed and will eventually be ordered from partnering countries? Developing countries do not need to take the same path, the same trajectory of growth and technological development, the developed world has taken. Certain stages of technology might simply be 'leapfrogged', as it is the case with unsustainable landfills. Also, a newly introduced high-end technology may do away with the need for other infrastructural changes thought to be necessary in following the developed world's example. Smartphones in rural Africa, for instance, have in many places substituted for direct contact with local agricultural advisors.

→ Upscaling is still an issue, particularly for climate finance. How can sectoral approaches be expanded to a national level? How can the private sector get involved on a larger scale? KfW generally favours projects that promise to have a broad impact, reaching at best hundreds of thousands of people.

→ There is a certain mismatch between the elaborateness of counselling and analysis at the beginning of a development project, and the speed of implementation, or rather lack of it, that follows. This often sets high-quality services, rendered by GIZ for example, against swift and prompt actions by less scrupulous providers.

→ Technology transfer so far has often been met with distrust among the local population. How can development cooperation help to dispel doubts and resistance? Do development officers always grasp the full extent of their clients' needs (and fears)?

→ The Alliance for Rural Electrification, in an effort to streamline its operations, has reviewed its geographical focus. Should GIZ do the same?

Cooperation with the Private Sector: Working group participants discussing results with moderator, Judith Helfmann-Hundack

... and solutions for cooperation with the private sector in the agriculture and food industry

→ Capacity-building should be strengthened, both in partner countries and at home.

→ In the same vein, collaboration with local universities should become a strategic target area for development cooperation.

→ Following the example of PPPs, climate partnerships and other such programmes with a broad and well-defined set of cooperation instruments, why not set up a participatory facility for technology adaptation? This could help build up trust among the local clientele. Associations could be mobilised to broaden its general impact.

Energy Efficiency in Thailand's Agro-Industries

Torsten Fritsche, *Senior Energy Manager, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*

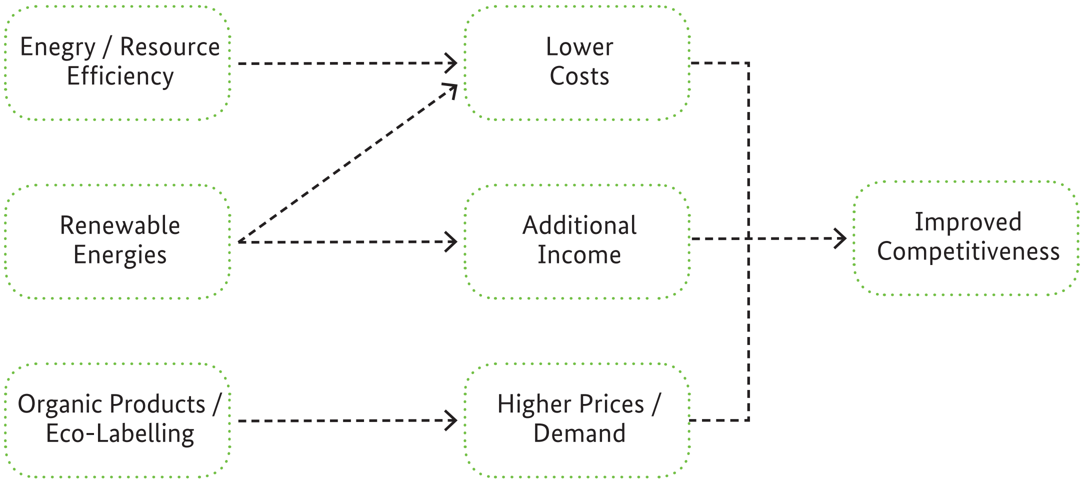
Thailand has been a prime focus for development efforts in recent years. Among the numerous programmes and projects launched by the EU and Germany, the Thai-German Programme on Enhancing Competitiveness of SMEs in the Agro-Industry in Thailand (TG-PEC), funded by the German Federal Ministry for Economic Cooperation and Development (BMZ), specifically targeted business and financial services as well as eco-efficiency throughout the country's five most important areas of agricultural production. These are: palm oil milling, tapioca processing, shrimp farming, fruit and vegetable processing, along with Saa paper production. Over the seven years of its duration, from May 2004 to December 2011, the programme analysed energy flows and production chains for a number of projects, chosen according to their various impacts on energy, agriculture and climate. Its approach for improved competitiveness was based upon three main pillars – resource efficiency, renewable energy and eco-labelling – all of which, it was hoped, would enhance Thai agro-businesses' performance by lowering costs, providing additional income and enabling higher prices, respectively.

Development Programmes/Projects with European/German Participation Based in Thailand

Climate, Environment and Energy	→ **Climate Policy Project (BMUB)** → **Energy Efficiency Development Plan (BMUB)** → **Project Development Programme: Renewable Energy in SEA (BMWi)** → Flood and Drought Prevention (BMUB) → The Economics of Ecosystem Services and Biodiversity (EU, BMZ, TH) → Water and Waste Water Companies for Climate Mitigation (BMUB)
Sustainable Consumption and Production	→ Sustainable Consumption and Production, SCP Policy (EU Service Contract) → Green Public Procurement and Eco-Labeling (BMUB → Greening Automotive Supply Chains (EU, BMUB, TH)
Regional Cooperation, ASEAN Integration	→ NEXUS Integrated Resource Management in Asian Cities (BMZ) → **ASEAN Biocontrol for Sustainable Agrifood Systems (BMZ)** → **Better Rice Initiative (PPP)** → Clean Air for Smaller Cities in ASEAN (BMZ) → Sustainable Port Development in ASEAN (BMZ) → Energy Efficiency in Transport in ASEAN (BMZ)
South-South and Trilateral Cooperation	→ **Trilateral Cooperation Programme with Thailand (BMZ, TH)** → **Trilateral Cooperation Programme with Malaysia (BMZ, MY)** → Global Initiative Disaster Risk Management (BMZ) → In-Company Training in the Mekong Region (BMZ and other German ministries) → Alliance for Financial Inclusion (Bill and Melinda Gates Foundation)

Explanation of acronyms for German ministries:
BMUB = Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
BMWi = Federal Ministry for Economic Affairs and Energy
BMZ = Federal Ministry for Economic Cooperation and Development

TG-PEC: Approach for competitiveness



TG-PEC: Technical and organisational solutions

The palm oil industry in Thailand produces large amounts of wastewater. In a model project initiated by TG-PEC, 60 to 70% of that could be used for methane-to-energy production in a biogas plant. Tapioca factories, by contrast, were found to be working under very poor safety and production standards, and generally with low regard for resource and energy efficiency. By offering training through a Management Information System (MIS), TH-PEC was able to significantly lower operational expenditure in seven facilities – an achievement quickly went on to attract other factory owners as well. Whilst in the beginning, training was offered at no charge, these latter operators were eventually willing to pay for MIS, as the model projects had proven to them that energy efficiency would pay off for their businesses. A significant cost item in shrimp farmers' bills is aeration, because the water of aquaculture ponds has to be stirred and filtered 24 hours a day. After a thorough investigation of the production chains and energy uses in shrimp farming, it was possible to reduce aeration duration in two pilot ponds in a TG-PEC model factory, thus saving 20% on the energy bill overall. Most of TG-PEC work in horticulture focused on 'longnan' processing – specifically, the drying of fruit for sale. By optimising the use of heating ovens and introducing sources of energy other than fuelwood – solar heaters, for example – up to 25% of energy could be saved in the operations of those factories under the programme's supervision. Similar changes also raised energy efficiency in Saa paper mills, which produce a traditional artisan paper made from the bark of the mulberry tree.

Obstacles to and opportunities for enhancing competitiveness through energy-efficiency measures

In all these applications, aside from seeking straightforward technical solutions, TG-PEC has always tried to mobilise industry and policy support. For example, funding projects through the United Nations' Clean Development Mechanism (CDM) was explored, and a Designated Operational Entity (DOE) established in the process. As per CDM statutes, a DOE ensures that a project results in real, measurable, and long-term emission reductions, so it can be registered and implemented under that scheme. Also, sustainable consumption and production (SCP) initiatives and programmes were appealed to where possible. A major boost, moreover, were business associations that disseminated success stories and programme information through their own networks. Demonstration projects are indeed of utmost importance for development work, as they serve to prove – to a generally hesitant local business community – the commercial value of new, clean energy-efficient measures and technologies. This hesitance is not simply a product of fear of the new, or of a general antipathy towards external interventions; it is often produced by the realities of pure market logic alone: rising energy prices increasingly render any changes to existing production systems a potentially ruinous endeavour. This means that fears must also be allayed with regard to technical feasibility. Benchmarking, and industry-wide communication of its results, has proven an effective method in this respect. It is equally important, however, to find qualified local service personnel who understand the necessary production processes required to run the alternate energy-efficient systems over the long term. Such personnel can act as decisive multipliers on a micro-level too, spreading the word within a company and its wider network.

Energy Efficiency in Ugandan SME

***Dr Babette Never,** Researcher, Department 'Sustainable Economic and Social Development', German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE)*

Over and beyond the purely technical – not to mention political – aspects of things in this domain, an additional way of looking at what drives the adoption of energy-efficiency measures in a developing context is from the perspective of social and behavioural science. What non-technical drivers, or barriers, are there that foster, or possibly impede, energy management and saving? What kind of thinking really spurs people's decisions when it comes to energy investments in a domestic or commercial setting? Furthermore, what habits and norms stand in the way of a broad-based diffusion of energy-efficient practices, when development cooperation has militated for a change in attitudes for decades already? These are the questions that DIE wanted to expand upon with a research project in Uganda, carried out in collaboration with the Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the Ugandan Ministry of Energy and Minerals Development (MEMD). Following up on professional training offered by GIZ within the framework of their Promotion of Renewable Energy and Efficiency Programme, DIE conducted 45 interviews with representatives from 29 small and medium-sized enterprises (SME) in Kampala and the eastern region of Uganda, roughly half of whom had participated in the training. Sixteen selected experts from the nation's capital took part in the survey as well.

Energy-saving potentials for the food processing industry in Uganda

There are at present 6,000 food-processing businesses in Uganda, which together employ about 60,000 people, according to the latest census from November 2011. Four persons, on average, work in each of the 2,700 grain mills throughout the country. These mills have an annual turnover ranging from below €1,500 (EUR; 50% of mills) to over €3,000 (20%), and cater for the most part to local communities, selling their products directly to end-consumers. As highly energy-intensive businesses, similar to the local metal and wood-processing industries, Ugandan grain mills spend a large part of their budget on electricity: it is currently charged at €0.10 to 0.16 per kWh for small and €0.09 to 0.15 per kWh for medium-sized enterprises, and accounts for 40 to 65% of business expenditure.

A further challenge to the businesses is the fact that Ugandan utilities are using bulk-metering, that is, they charge their clients in groups rather than individually. Originally introduced to counter electricity theft, bulk metering has the potential to instigate more awareness of electricity consumption and energy saving as it imposes a strong social control. If one group member cheats, the costs of the bill are borne by the other members of a bulk metering group. Currently, the system creates a lot of frustration and mistrust among SME owners, undermining the potential positive effects of the system. In those groups with high mistrust and many irregularities, switching to individual metering would already represent a boost for energy efficiency in its own right. There are, however, other potentials for energy saving in grain mills. Motor and huller sizes and speeds could be adjusted for an optimal, most energy efficient mode of operation. Compact fluorescent lamps and translucent sheets, to cite another example, might be used for lighting instead of conventional filament lamps. Perhaps the biggest saving potential of all, however, resides with a rather basic move: simply replacing old machines with new ones. Modern hullers could reduce the

number of times that the grain needs to pass through the machine from three to one, thus saving about the same rate in energy.

Obstacles to long-term investment and 'behavioural barriers'

That rather simple changes to machinery and equipment as outlined above have not yet taken place to any great extent in Uganda, is largely owing to lack of finance. Interest rates for bank loans are at a prohibitive 22 to 25% per annum. In micro-financing, they hover at 4% per month. Equity capital is likewise lacking, though the 'perceived' lack of funds might actually be higher than the 'real' one, as Ugandans, even in management positions, often have ill-conceived ideas about the cost of renovations, or they simply are not aware of the most advanced, clean, and affordable, technology. Most of what is currently used in agricultural production and processes in Uganda is second-hand machinery, at least one generation behind of what is now considered state-of-the-art in the developed world. To this problem of obsolete machinery one must add the problem of a certain mind-set, making it difficult for innovations to take proper foothold. From within their corporate hierarchy, it seems, people in Uganda seem to think along much shorter timeframes than what most clean-energy applications would require, to achieve amortisation. Long-term planning – that is, exercising self-discipline for delayed gratification – is not common in Ugandan commercial or everyday Ugandan culture. What is more, there is a strong preference for the status quo: 'Why should I change my machines when they are still working just fine?' This kind of thinking is both favoured and fuelled by deep misgivings about utilities, contractors, and vendors in general. Instead of feeling at the mercy of new technologies provided by strangers they do not yet fully trust, the people of Uganda would rather stick to the(ir) old ways, even if these ways are shown to be now outdated and thoroughly inefficient.

Behavioural drivers and their implications for future programmes

All is not lost, though, for DIE's research study also identified behavioural drivers that could foster and increase energy efficiency. One such driver is that of direct, hands-on experience – as is generally thought to be delivered via model projects. If people see with their own eyes just what a technology can achieve for them, and if, they get to operate this technology for themselves, a cognitive process of appropriation might be instigated that culminates, in ownership. Feedback from peers and social comparison with others that have already made significant changes, will additionally bring on a innovative ardour. By experience, communication that stresses the reality of a concrete loss rather than a potential gain, is often far more effective in prompting people to action, e.g.: 'You will lose Shs500 a week if you do not have the full number of belts on your machine.' For future programmes in development cooperation, this implies above all a toned-down, less technical, less bureaucratic approach: make it simple, make it social – make it, in a word, sexy. One's project should be designed in a way that allows for a maximum of practical experience to be gained by those whose businesses one has in mind. Obvious examples here are via local demonstration and information centres, and/or pilot SMEs. Communication with clients must be continuous and must provide up-to-date information. Why not reach out to project participants with, say, text messages every week? The ultimate aim in any effort should be to trigger commitment at an accessible threshold, that is to say, by means of affordable training, and verily to stimulate a desire for implementation in training participants, one that lasts well beyond the training event itself, e.g.: 'When I am back at my company, I will check and record my electricity consumption every morning.'

Overall, it is necessary to combine behavioural interventions with measures that target other barriers like access to finance or to efficient, affordable technology in order to achieve the maximum effect possible. Targeting behaviour belongs in the larger toolbox of development policies.

Presentation of Results: Energy Efficiency – A Potential Gain for Agro-Industries (Working Group II)

Torsten Fritsche (left), Dr Babette Never (centre) and moderator Dr Anna Pegels (right) developing first ideas for the challenges and solutions mind-map

Moderator: Dr Anna Pegels, *Researcher, Department 'Sustainable Economic and Social Development', German Development Institute / Deutsches Institut für Entwicklungs-politik (DIE)*

Challenges...

→ Electricity prices are both a boon and a bane for energy-efficiency investments: rising as they are, they may indeed prompt energy-intensive businesses to rethink their energy management and make the switch to renewables; on the other hand, operators may as well shy away from investments when their finances are already strained by a massive electricity bill (up to 75% of all expenditure for some agrobusinesses), or, given the weight of energy in their budget, because it is not fully clear how, and in what time-span exactly, these investments will contribute to alleviating their overall costs.

→ Electricity pricing on the part of utilities may sometimes play into the hands of energy wastage ironically. If providers use bulk metering, charging their clients in groups rather than individually (such as is the case in rural Uganda), they give in fact free rein to inconsiderate, extensive use of electricity, as the bills of cheaters and/or large consumers are eventually borne by the majority in a metered group. Switching to individual metering here already represents a boost for energy efficiency in its own right.

→ Much needed renovations of outdated and energy-guzzling machinery may be impeded by lack of funds. Interest

rates in developing countries, even in the case of microfinance, are often prohibitive, so credit is not an option for the financing of new installations in most cases. Equity capital, on the other hand, is also always in short supply with small and medium-sized enterprises, which either do not have the turn-over, or the maturity, to accumulate large amounts of capital for investment. The 'perceived' lack of funds, however, might actually be higher than the 'real' one: people, even in management positions, often have false ideas about the cost of clean energy, or they do simply not know about the most advanced, and affordable, technology.

→ A lack of information about what is available, and what indeed would be appropriate for enhancing their businesses, is a serious issue for operators of agricultural processing facilities in the developing world. Most of what is used in production and processing in Uganda, for instance, is second-hand machinery, at least one generation behind of what is considered the current state of the art.

→ Throughout corporate hierarchy, people in Uganda (and other developing countries) seem to think in much shorter time frames than what most clean energy applications would require to reach amortisation. Long-term planning – that is, self-discipline for delayed gratification – is not common in Ugandan commercial and everyday culture. Also, there is a strong bias for the status quo: 'Why should I change my machines when they are still working just fine?' This kind of thinking is favoured and fuelled by a deep mistrust towards utilities, contractors and vendors in general. Instead of being at the mercy of new technologies provided by strangers they do not trust, Ugandans rather stick to the(ir) old ways, even if these are fairly outdated and thoroughly inefficient.

→ The question of qualified personnel should be a top priority on the agenda of project managers in development cooperation: if newly introduced energy-efficient systems are to operate successfully beyond the duration of a project, that is, without external assistance in the long run, they should see to it that there is also well-trained local service staff that understand the machines and processes necessary.

... and solutions for energy efficiency in the agriculture and food industry

→ When it comes to enhancing competitiveness through eco-efficiency, benchmarking has proven a very effective tool. By making available data from businesses in a given sector and promoting these as best-practice examples, development officers can incite others to act on their energy consumption and management as well.

→ Likewise, demonstration projects may serve to prove the commercial value of energy-efficiency measures and the introduction of new technologies. Direct, hands-on experience is in fact a powerful behavioural driver. If people see with their own eyes what a technology can achieve for them, and if, moreover, they get to operate this technology themselves, this will instigate a concrete cognitive process of appropriation and ownership. Feedback of the kind given in benchmarking might further fan innovative fervour.

→ By experience, communication that stresses a real loss rather than a potential gain is more effective in prodding people into action, e.g.: 'You will lose Shs500 a week if you do not have the full number of belts on your machine.'

→ For future programmes in development cooperation, this means above all a toned-down, less technical and bureaucratic approach: make it simple, make it social, make it attractive! Projects should be designed in a way that allows for a maximum of practical experience to be reaped by those targeted. The ultimate aim in any effort should be to trigger commitment at an accessible threshold, that is, through affordable training, and to build up an intention for implementation on the part of training participants that lasts well beyond the training itself, e.g.: 'When I am back in my company, I will check and record my electricity consumption every morning.'

→ Communication with clients should always be continuous and up-to-date. Business associations can be tapped to disseminate success stories of programmes and latest information through their networks (with the intention of triggering action, as described above). Staff of model projects can act as decisive multipliers on a micro-level too, spreading the word in a company and its local communication channels.

→ Finally, the deep mistrust that reigns in many developing countries towards utilities and government agents may be turned to good use by making this a further argument for local, off-grid renewable energy installations.

Solar Pumps for Irrigation: Experiences, Status and Perspectives

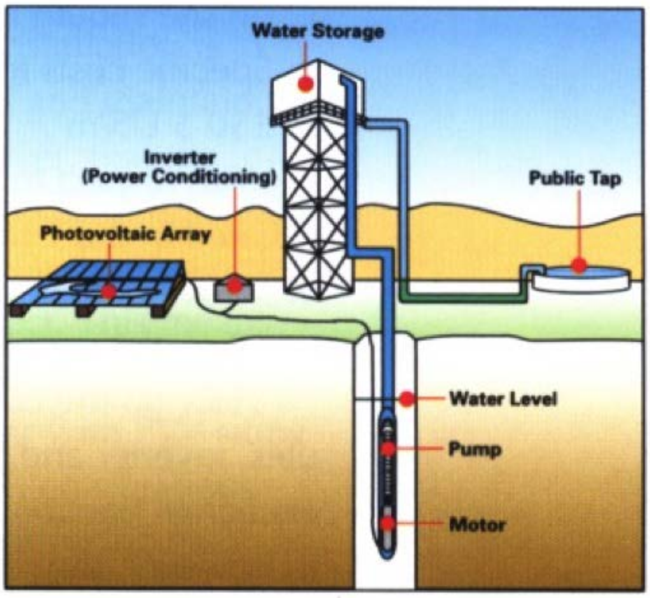
Dr Rolf Posorski, *Senior Planning Officer, Competence Centre 'Energy', Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*

Irrigation requires energy. Even in systems like terrace fields along mountain streams, or seasonal floodland along larger rivers, energy plays a significant role – though it is hidden here in the form of gravitation or flow. This natural water flow, which comes free-of-charge (notwithstanding the effort required for building canals and terraces in general), has been used for millennia. However, it also has critical limits, as land around naturally occurring water reservoirs is finite (and may be coveted for other land uses, too). Irrigation through pumping of ground or surface water developed almost as early as these more traditional, passive forms of irrigation and made it possible to add land for agricultural cultivation. In this respect, solar pumps are a valuable tool in agricultural production. Their use for either increase of output or reduction of costs should however always be premised on a thorough analysis of the market and demand for the product as well as of production costs. Both issues are essential to judging the profitability of a solar pump, particularly in the context of smallholder agriculture.

Solar Pumps for Irrigation: Layout, Components, Capacity

Standard components

- → Solar panel (kWp)
- → Inverter/Motor/Pump (kW)
- → High-level tank/Reservoir/Distribution system



Solar radiation

- → Season- and site-specific
- → Sufficient international data for dimensioning
- → Solar irradiation on clear, sunny days approx. 5–6 kWh/m^2

Water output

- → *Empirical estimate of solar pump performance:*
  1 kWp delivers over clear, sunny days 500 m^4/day

- → *Example for different pumping heads:*
  X m^4/day = Pumping head * Water output
  Low pumping head: 500 m^4/day = 10 m * 50 m^3/day
  High pumping head: 500 m^4/day = 50 m * 10 m^3/day

Solar pumps – nothing new under the sun

First field studies with solar pumps go back as far as the 1980s. A GIZ programme, funded jointly by the German Federal Ministries of Education and Research (BMBF) and Economic Cooperation and Development (BMZ), ran over 12 years from 1989 to 2001 in nine countries with about 100 solar pumps on trial. An EU-funded solar programme tested approximately 1100 pumps in seven countries of the Sahel zone from 1990 until 2009. Though the main aim of these projects was supply of drinking water, their field data and findings provide a good data base for irrigation as well. Generally speaking, solar pumps have reached technical maturity and allow for reliable operation; there exist enough validated data for adequate cost-benefit analyses.

Solar radiation is highly variable, depending on season, location and day, but empirical data now allow for an estimation of water output: with a nominal power of 1 kWp, for instance, a solar pump should deliver about 500 m^4 of water on a clear sunny day. Of course, proper dimensioning of pump components is always required for each individual site as well. During the last decade, a number of product improvements have considerably facilitated planning, installation and maintenance of solar pumps. Prices of solar modules have fallen significantly with increasing market penetration. A network of local dealers nowadays allows for procurement and repair of solar pumps almost everywhere. Are solar pumps the once-and-for-all solution for irrigation in developing countries then? Not quite.

Solar pumps in every place? Economic and environmental aspects

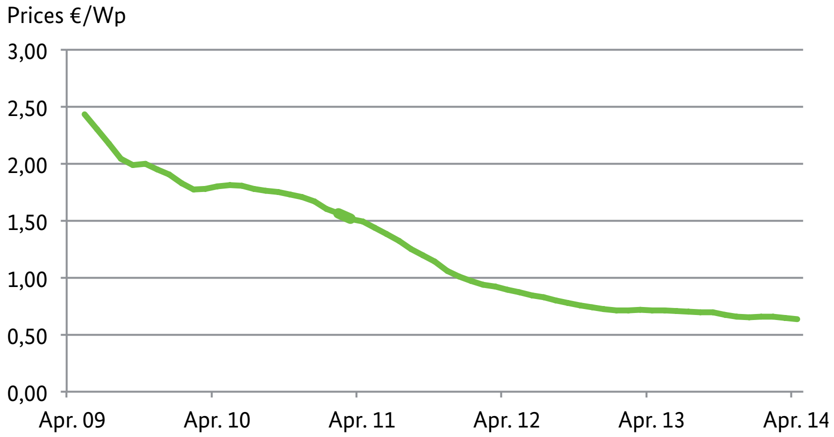
Where available, a grid-based power supply is generally the most cost-effective alternative for operation of irrigation pumps – unless there is a high risk of blackouts or load shedding. In areas with no access to grid electricity, solar pumps have a major competitor in diesel-powered water pumps. The odds here are surprisingly even at first glance: in comparison to their solar-powered counterparts, diesel pumps have relatively low investment costs. Their operation and maintenance costs, on the other hand, are much higher, and the difference is indeed most pronounced in low capacity ranges, that is, where the higher upfront costs for solar installations do not play out yet. Also, diesel pumps are less reliable in terms of break-down and failure, and are at a clear disadvantage when it comes to greenhouse gas emissions and environmental impact. Their life-cycle emissions are about 10 times higher that those of solar pumps (including the CO_2 footprint of the solar modules used with the pumps); for harmful sulphur dioxide and nitrogen oxide it reaches up to 50 times and higher. Yet, despite their immaculate environmental record and low operation costs, solar pumps are handicapped by the higher investment costs they require. They are profitable in those situations and places where capital interests (for repayment of loans for upfront costs) are low or moderate, where solar radiation is generally high (or pumping less needed in rainy seasons) and where the water pumped over seasonal cycles is fully used for agricultural production, e.g. for permanent crops.. Diesel pumps, in contrast, may be more competitive for short-term seasonal irrigation with high peak water demand.

Solar Pumps for Irrigation: Technology and Market Development

Development of technology

- Screw pumps:
  improved efficiency for lower pumping head
- Novel electric motor for pumps:
  improved starting and variable input voltage (30–300 V DC and 90–240 V AC)

Development of prices for solar panels



Market for solar pumps

- No validated global sales statistics to date!
- Estimation: 30–40,000 per annum

Suppliers and Dimensioning

- Major companies nowadays offer detailed, ready-to-use data for dimensioning of solar pumps.

Examples of solar irrigation: Experiences and perspectives from Chile and Ethiopia

The GIZ programme mentioned in the beginning, by its official title 'International Field-testing and Demonstration Programme for Photovoltaic Water Pumps (PVP)', demonstrated as early as the 1990s the benefits and limits of solar pumps as sketched above. At its project sites in Chile and Ethiopia, it found that irrigation with solar pumps were in fact well suited for small-scale agriculture and forestry. While operation of solar pumps generally requires a higher level of management skills from smallholders, these systems proved in practice to be technically reliable and to be real economical alternatives for local farmers, who until then had been dependent on Diesel pumps alone.

Solar Pumps for Irrigation: Conclusion

- In most ranges of performance, solar pumps have proven technically, economically and ecologically superior to diesel pumps.
- Irrigation using solar pumps is a promising and economical alternative in many cases; however, it presupposes a clear analysis of agricultural value chains and management requirements.
- The introduction of solar pumps for irrigation in smallholder operations requires agro-technical advisory assistance and financing of upfront costs.
- Environmental and climate concerns in the face of a growing need to step up agricultural production and decentralize agricultural processing and value-adding call for further in-depth research into solar irrigation, its limits and opportunities.

Solar Energy in Agriculture

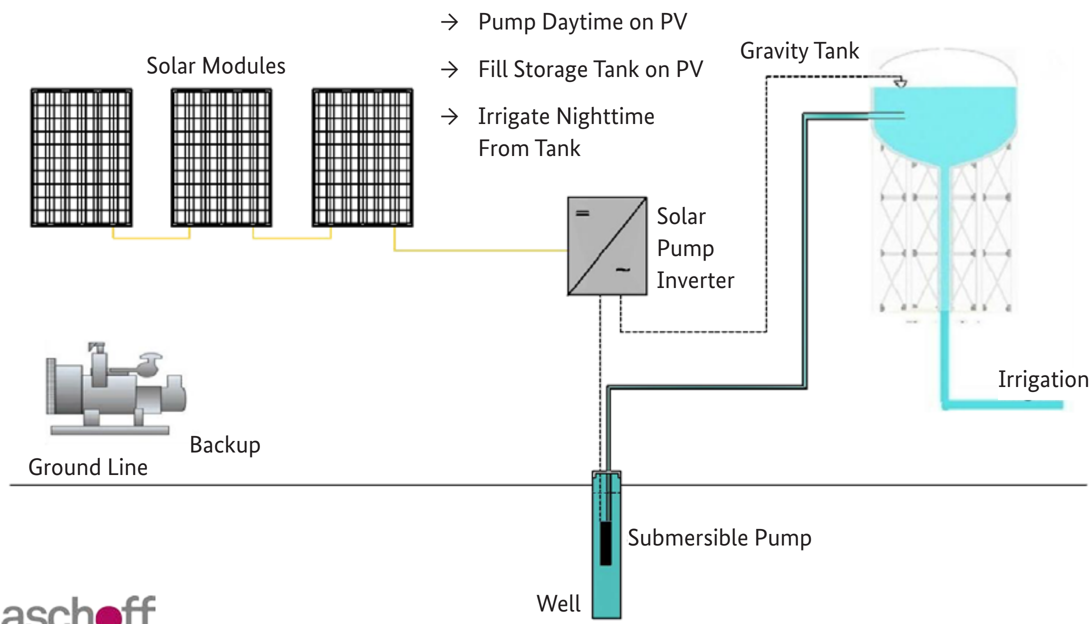
***Karina Rita Boers,** PPP Advisor 'Agricultural Water Productivity as Adaptation to Climate Change', Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Egypt*

Combining 'Ra', the ancient Egyptian solar deity, with 'Seed' to form a word which pronounced in Arabic would translate as 'deposit' or 'saving', RaSeed proves not only to have a handle on cross-cultural branding, but skilfully inscribed in its corporate name the very essence of its work: advising agricultural companies in Egypt on how to harness the sun for cultivation purposes, particularly for irrigation.

Agriculture in Egypt and its challenges

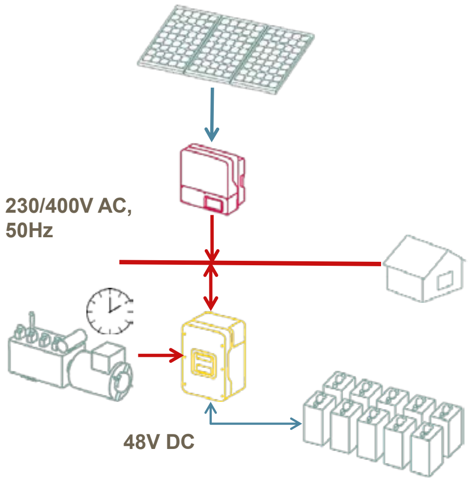
Solar energy in agriculture does not necessarily and at all times equate to simply selling fully operational solar pumps. RaSeed specializes in linking up PV arrays to existing off-grid systems, thereby powering water pumps that would otherwise depend on diesel generators for their energy supply. The impact of this on Egyptian agriculture, and on its economy, could be considerable indeed, as slightly more than half of the population in Egypt (54%) still lives off agricultural production and services. What is more, with both quantity and quality of water from the Nile now in steady decline, and with a riverside agriculture restricted to small, even minuscule holdings – 90% below 2.5 ha – Egyptian agriculture is shifting into the desert, where much larger farms of about 2,000 ha on average now cultivate 'new lands' under a somewhat more commercial, more profit-oriented regime. It is these farms that RaSeed targets for building a solar market for off-grid solutions in Egypt. Insofar as they have new seniority, size and status, it is hoped, these farms will ultimately have a trickle-down effect all the way to the fellaheen level of agriculture. Regardless of farm sizes, however, the greatest challenge to Egyptian agriculture remains that of energy scarcity. Diesel is heavily subsidised by the State, but production and import in an economy still stunned by the spell of the 'Arab Spring' cannot yet meet demand. This has particularly dire consequences for the 'new lands', as these are mostly too remote to be grid-connected, and are thus entirely reliant on energy from generators. Reports detailing severe harvest losses due to drought and financial hardship continue to emerge to this day.

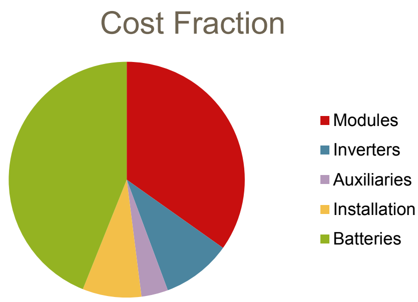
Solar Pump with Water Tank



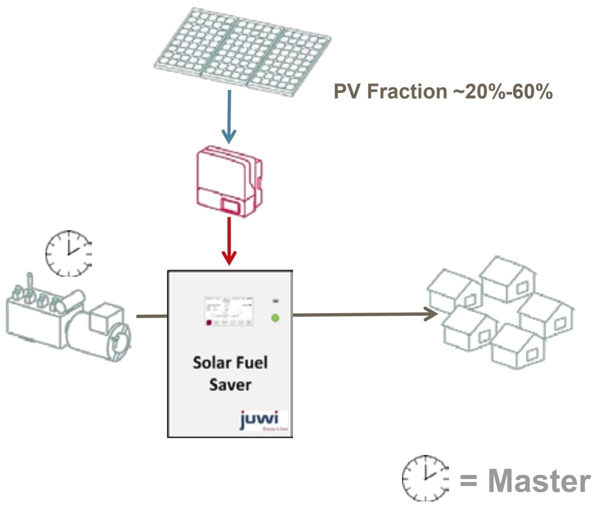
Source: aschoff solar

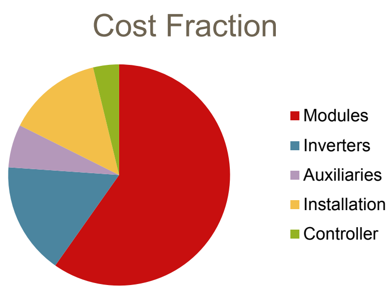
Hybrid System with Battery (Figure 1)



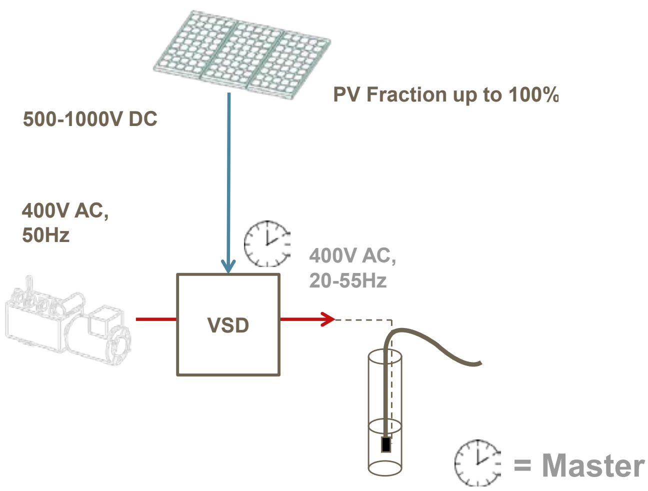


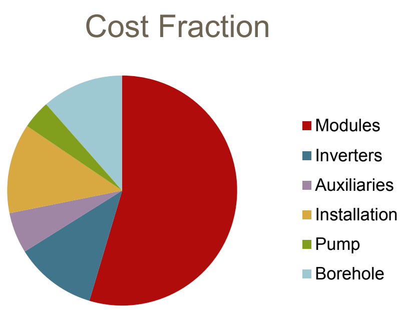
Solar Energy as Fuel Saver (Figure 2)





Solar System with Variable Speed Drive (Figure 3)





Source: juwi Die Energie ist da

Off-grid solar systems for irrigation: Layout options and costs

Adding solar panels to off-grid systems under these conditions promises not only to reduce fuel costs and stabilise energy supply, but also to enhance domestic food production and security in the long run. There are several options for integration: either solar pumps can work independently and for instance fill an external water reservoir during daytime, which is then emptied overnight – the most conventional of applications – or they can provide supplementary energy to a basically unaltered power system, that is, a system where a generator covers some or most of the base load. Here, the PV panels may feed into batteries in what amounts to hybrid system (see page 56 figure 1), where the energy stored will subsequently be used for agricultural and/or home devices. This relieves a farm of round-the-clock dependence on either grid or generator, but also tends to be fairly expensive. Or, pumps may feed directly into the micro-grid (see page 56 figure 2) of a farm and thus allow the generator to run at a reduced level during daytime (20 to 30%, normally), while resuming full provision at night. The most cost-effective and efficient set-up, however, is an installation with a so-called 'variable speed drive' (VSD) (see page 56 figure 3), which ensures that irrigation during daytime is powered solely by PV, but automatically switches back to generator-supply in the evening and at night. In either of these scenarios, PV modules represent a substantial, if not the biggest portion of overall costs, since a special heat-resistant variety of PV cells is required for operation in the extreme climate of the North African desert, with temperatures reaching as high as 54° C. The pumping systems, therefore, come at a considerable price: €200,000 to 300,000 for a PV installation with VSD and a nominal power rating of up to 200 kWp, which is able to irrigate from 20 to 40 ha of desert land.

GIZ and RaSeed: Current projects and future prospects

GIZ, through RaSeed, works actively to establish networks with trading and development banks that may help shoulder the high investment costs associated with solar pumping. This is because interested companies are obliged as per RaSeed statutes to acquire these installations at 100% ownership, which in many cases involves taking on loans and credits, as equity capital is generally scarce in Egypt. GIZ also offers training focused on PV and/or irrigation for workers on partnering farms. Participants are meant to adopt and act on suggestions for improvement of agricultural practices and pump dimensions (with particular regard to water productivity). Some of these proceed directly from feasibility studies that are also initiated and funded by GIZ in Egypt. To date there are three main projects piloted by RaSeed and GIZ, and each of them works with a different integrated solar system: Bahareya Oasis, an organic date farm that built a 55 kWp full solar system; Wadi El Natroun, an olive farm that will be equipped with a 150 kWp battery hybrid system; and lastly, the Mansoureya peach farm of PICO agriculture that will start using a fuel saver system for its four pumps of ca. 288 kW. One major problem for pilot projects and their replication in the Egyptian setting is the lack of local suppliers who can offer high-quality materials plus the know-how necessary to keep the systems up and running. GIZ tries to bridge this gap by bringing together European and Egyptian solar companies in order to increase know-how exchange and create partnerships that will enhance the technology supplied and the services offered for maintenance. In fact, an international solar energy conference, held in 2014, with participants from the banking sector present as well, has already served this very purpose.

In the past one and a half years, thus, a lot has been achieved for solar pumping in Egypt. There now exists a dynamic network of partnerships between international and local solar companies, banking cooperation with agribusinesses and solar companies has taken off successfully, and technical guidance for solar energy installations is available throughout the country. Numerous technical trainings were held; chief among them is a series of workshops that introduced solar energy standards for off-grid pumping systems in the desert, specifically adapted to the Egyptian setting and the Middle-East and Northern African (MENA) region; its results have been published as well. Irrigation manuals for a more water-productive desert agriculture now circulate in the Egyptian market. Also, an economic model for calculating the performance of solar pumping systems has been made available to offer interested companies a look into how a shift from conventional energy sources to solar energy can profit their businesses. All these steps should allow for a true solar energy community to take hold in the long run – one whose very presence may allow fresh alliances and considerations of strategy, crossing both national boundaries and economic sectors.

For more information on and/or access to the guidelines, economic models, studies and experiences within the pilot projects, please visit RaSeed on www.raseed-giz.com

Presentation of Results: Optimising Agricultural Irrigation from an Energy Perspective (Working Group III)

***Moderator: Bernhard Zymla,** Head of Competence Centre 'Energy', Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*

Challenges and solutions for optimising agricultural irrigation: An inseparable field!

→ In areas without access to the grid, solar pumps have proven generally superior to diesel-powered water pumps – both in terms of technical reliability and operational economy, as well as environmental impact. This does however not hold for all contexts and scenarios. Where credit is hard to come by (high interest rates) and/or pumping only needed in short cycles or for short periods of time (seasonal irrigation peaks), diesel generators may be the more cost-effective alternative. This is true in particular for small-scale applications, where the low operation and maintenance costs of solar pumps cannot yet fully compensate for the higher initial outlay these systems require in comparison to diesel generators. Also, subsidies for diesel fuels – common to this day in many developing countries – may raise the threshold for market entry of solar pumps.

→ With the profitability of solar irrigation systems depending on a multitude of country-, culture- and site-specific parameters, it is all the more important to conduct a thoroughgoing preliminary analysis prior to introduction (feasibility study, cost-benefit analysis, risk assessment). This investigation should address the agricultural value chains and management requirements at issue in each case; the broader technical, economic and environmental factors that might affect a project at a given site (hydrology in particular); and also – though this often escapes project planners – the social, cultural and political climate that obtains where an intervention is to take place.

→ Solar pumps have reached a level of technical maturity that allows for reliable operation in most settings, and there exist today sufficient (validated) field data to make robust estimates of water output and compute component dimensions for almost all types of pumps and sites. However, what is still missing is a systematic (international) assessment and consolidation of data gathered within individual projects around the world. Documentation and knowledge transfer among peers are indispensable, especially where examples of practice are still rare. In the case of solar pumps, for instance, demonstrations are still needed with regard to operation modes: what systems have proven effective, and most manageable, for smallholders or under collective ownership, in cooperatives and associations? What mobile applications exist to date? What experiences have been made with retention basins, for example?

→ While small-scale applications and scenarios have received a lot of critical attention in recent years, research on systems exceeding 100 kW in capacity is to a great extent still lacking. Off-grid solar systems notably should be the focus of statistical research and field testing in the future (monitoring of parameters and conditions assumed in calculations). For small-scale systems, in contrast, the focus in project work should shift from research and development to active, broad-based implementation.

→ Photovoltaics are a rather high-end, sophisticated technology in the range of renewables and require a certain amount of knowledge, skill and experience for assembly and operation. This is often lacking on the part of local suppliers and service providers (though international project staff may be just as inexperienced). Moreover, lack of competition owing to the limited number of specialised companies in an emerging market often tends to hamper product improvement. The quality of components (and/or entire systems) which have been procured locally is in many cases rather poor in consequence. Imported products do not necessarily fare any better as experience in handling.

these may be severely limited too. Capacity-building, hence, remains a central issue for solar irrigation – in the sense not only of on-site training offered within the framework of a given project, but also, and more importantly, of links and partnerships established between local and international solar companies so as to prompt commercial knowledge transfer. Likewise, business models should be developed with suppliers that take into account the specific needs (and knowledge gaps) of local agrobusinesses, thus boosting adaptation by increased demand.

→ The general lack of experience, in both technical and commercial terms, also translates to a generally hesitant financing environment. Banks consider the risk levels for solar irrigation projects to be still not sufficiently clear or predictable for their purposes, and so often withhold affordable credit. Further research, and accumulation of validated data, promises to ameliorate the wider prospect here, both for micro-credit and for larger international endeavours in the long run. Development cooperation can work to speed up the process by offering a platform for banks to meet local entrepreneurs and develop locally adapted services.

→ Aside from all these very practical challenges, there is however another fundamental issue with regard to solar pumping that needs to be addressed: increased use of water pumps, be they solar- or diesel-powered, affects local water tables. Ground water levels in Egypt, for example, have continuously fallen in recent years under the country's heavy irrigation regime. How does development cooperation position itself in relation to environmental damage brought on by an agricultural practice that it is itself promoting in other respects? Is agricultural irrigation "optimised from an energy perspective" commensurate with sustainability at large? This question concerns other phenomena as well – salination of soils, for example, which incidentally has been found to be a major problem for Egyptian smallholdings that use pumped groundwater for irrigation.

Joachim Went of Fraunhofer Institute for Solar Energy Systems ISE presenting the workshop's findings in the concluding plenary session

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